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SCIENCE AND TECHNOLOGY

SELECTIONS ON '757' VECTOR COMPUTER

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8 JULY 1986

CHINA REPORT

SCIENCE AND TECHNOLOGY

SELECTIONS ON '757' VECTOR COMPUTER

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Nos 2, 5, 8, 10, 1984

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CHINA'S FIRST LARGE VECTOR COMPUTER

Beijing [JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 2, 1982 pp 1-2

[Article by Wang Shuhe [3769 2885 0735], Institute of Computing Technology, Chinese Academy of Sciences (CAS): "The 10-MIPS 757 Vector Computer System Passes State Evaluation"]

[Text] The State Evaluation meeting of the "757" 10-MIPS [million instructions per second] computer system was conducted from 13-15 November 1983 in Beijing. The meeting was carried out by a State Appraisal Board authorized by the State Council's Computer and Large-Scale Integrated Circuit Leading Group. The session was attended by 120 representatives of 50 units nationwide. Comrade Fang Yi [2455 3015], State Council member and State Scientific and Technical Commission chairman, and CAS Director Comrade Lu Jiaxi [4151 0857 6932], spoke at the meeting.

The State Appraisal Board, consisting of 26 eminent Chinese computer experts and leadership personnel from the various departments concerned, worked conscientiously at the conference. It heard the research report delivered by Comrade Wu Jikang [0702 0415 1660] on behalf of the CAS Institute of Computing Technology, which developed the "757," the technical evaluation report made by Comrade Jin Yilian [6855 1837 3425] on behalf of the Technical Evaluation Group (see appendix), and reports by four subgroups of the Technical Evaluation Group. The board also studied all related documentation and technical data. Ultimately, it unanimously granted state certification for the 10-MIPS 757 computer system and held a signing ceremony.

The State appraisal certificate says the following:

After conscientious discussion, the State Appraisal Board has concluded that the technical evaluation report of the 757 machine corresponds with the actual situation and is appropriate. The board has decided to approve this report. The 757 machine is China's first exclusively Chinese-developed large vector computer. An investigation of the results has revealed that the principal technical and reliability indexes either meet or exceed the requirements of the appraisal guidelines. The State Board certification of the "757" is an important mark of China's increased level of capability in R&D of large computers.

The "757" is the fruit of self-reliance and energetic cooperation, and the result of close coordination between research, production, and user units. The development of the "757" has accumulated experience for China's program of independent development of large-scale computers. In addition it indicates that the CAS Institute of Computing Technology has an outstanding technical contingent which is a valuable national resource and which should be more effectively utilized in the future.

The State Appraisal Board concludes that large-scale computers are essential to modernization. It hopes that all departments concerned will continue their efforts in strengthening basic and developmental work in computer technology, and in planning for the coordinated development of superlarge-, large-, medium-sized, mini- and micro-computers for making greater contributions to developing China's work in the computer field and to the four modernizations.

Appendix: The Technical Appraisal Report on the "757" 10-MIPS Computer System [Excerpts]

The "757" is a large computer system which was independently designed and experimentally developed by China. The objective of its development was to solve large-scale scientific and engineering problems arising in China's economic development and scientific research. The CAS Institute of Computing Technology, the principal unit responsible, conducted the "757" research and development over a period of several years with the help of cooperating units, using China's own resources.

The Technical Evaluation Group conducted the technical evaluation of the "757" from 3 August to 12 November 1983. Its conclusions are stated below.

I. Hardware

The 757's hardware system includes a mainframe, a peripheral processor and various peripheral devices. The Evaluation Group has tested the hardware. It has carried out frequency-shift, power-supply variation and noise immunity tests on the various components, as well as testing the speed of the machine. It has confirmed that the 757's operating speed, the performance of all components of the "757" machine and all peripherals, and the range of stable operation of the entire machine meet the required indicators of the evaluation guidelines.

II. Software

The 757's software system includes an operating system, a vector FORTRAN compiler, a mainframe assembler, a peripheral processor, internal function subroutines, a basic graphics package, a diagnostic program and a double-calculation program.

The Evaluation Group investigated the operating system's capabilities and reliability. It examined the vector FORTRAN compiler's correctness and error reporting capability and analyzed its efficiency. In addition, an

analysis was made of the assembler, the basic graphics package and the internal function subroutines, and the diagnostic and double-calculation programs were tested. It was concluded that the 757's software system meets the requirements of the evaluation guidelines.

III. Problem Solving Tested

In order to investigate the actual computational capability and reliability of the "757," between May and October 1983 we ran on the mainframe machine 30 assembler problems, 10 vector FORTRAN problems, and 25 scalar FORTRAN problems. These problems represented a wide range of users. The runs indicated that the computation results were correct and the precision met the requirements.

IV. System Reliability

From 24 October to 8 November 1983, we carried out a 15-consecutive day reliability test of the "757," including multiprogramming operation. During the testing period, we ran test programs with known results designed particularly for checking the mainframe and the peripheral processor. Statistics indicated the following:

$$\text{System mean time between failures} = \frac{\text{total time of normal operation}}{\text{number of failures} + \text{number of jitters} + 1} = 120 \text{ hours}$$

$$\text{System mean time to failure} = \frac{\text{total time of normal operation}}{\text{number of failures} + 1} = 120 \text{ hours}$$

$$\text{System availability} = \frac{\text{total time of normal operation}}{\text{total time of normal operation} + \text{total maintenance time}} = 99.8 \text{ percent}$$

The above results all exceeded the requirements of the evaluation guidelines.

The Technical Evaluation Group discussed the results of the evaluations and unanimously concluded that the "757" machine is the first large exclusively Chinese-developed vector computer. It was built on the basis of China's then current technical capabilities and with Chinese-made components and equipment. In system design, the concepts of vector crossbar in-processing [zongheng jiagong [4912 2897 0502 1562]] and multiple [duo [1122]] vector accumulator were independently proposed. In logic design, pipeline and overlap techniques were adopted. Vector operations reached 10 million per second, and scalar operations reached 2.8 million per second. The peripheral devices are relatively complete. The system software is also fairly complete. A FORTRAN-77 compiler developed earlier in China and its vector functions were expanded. The operating system has a multiprogramming capability. The system also makes use of checking, correcting, double-calculating and diagnostic techniques, has effectively increased machine reliability, availability, and maintainability. Tests indicate that the machine is stable and reliable and that its principal technical and

reliability indexes either meet or exceed the requirements of the evaluation guidelines. The machine has excellent performance capabilities.

The development of the "757" machine was based on domestic technical capabilities and made use of domestically produced materials and equipment, which stimulated the development of China's basic computer components and processes. Computer-aided design (CAD) was used during the R&D period that not only speeded up the engineering process, but also promoted the development of domestic CAD technology.

The "757" machine is the fruit of self-reliance and large-scale cooperation and the result of close coordination and common effort between development, production, and user units. Overcoming difficult problems related to new technologies and processes, more than 80 units of the CAS Institute of Computing Technology and more than 30 departments and localities nationwide cooperated on a large scale. The successful development of the 10-MIPS "757" system has provided experience that is usable in China's independent large computer development project.

The Evaluation Group has also concluded that in the future we must further develop software suited to the characteristics of the "757" and energetically pursue computation and algorithm research so as to make the fullest use of the 757's high-speed problem-solving capabilities.

8480/9365

CSO: 4008/199

INTRODUCTION TO 757 VECTOR COMPUTER SYSTEM

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 2, 1984 pp 3-6

[Article by Wu Jikang [0702 0415 1660], Zhao Renchang [6392 0088 2490], and Wang Zhenshan [3769 2182 1472], Institute of Computing Technology, Chinese Academy of Sciences (CAS)]

[Text] In order to solve large-scale scientific and engineering problems arising in China's four modernizations, the CAS Institute of Computing Technology (shown in Figure 1) recently developed China's first 10-MIPS large computer, the "757" machine (see Figure 2). Its development has successfully raised the level of China's computer research and development activities and has promoted the development of computer science and technology in China.



Figure 1. One of the Research Buildings of the CAS Institute of Computing Technology

The system hardware of the "757" consists of a vector processor (mainframe) and a peripheral processor (see Figures 3 and 4).

The general design approach in the mainframe is that of a crossbar in-processing [zongheng jiagong [4912 2897 0502 1562]] vector machine. Its characteristics are based on China's national situation, the multiple [duo [1122]] vector accumulator concept was introduced into its design,

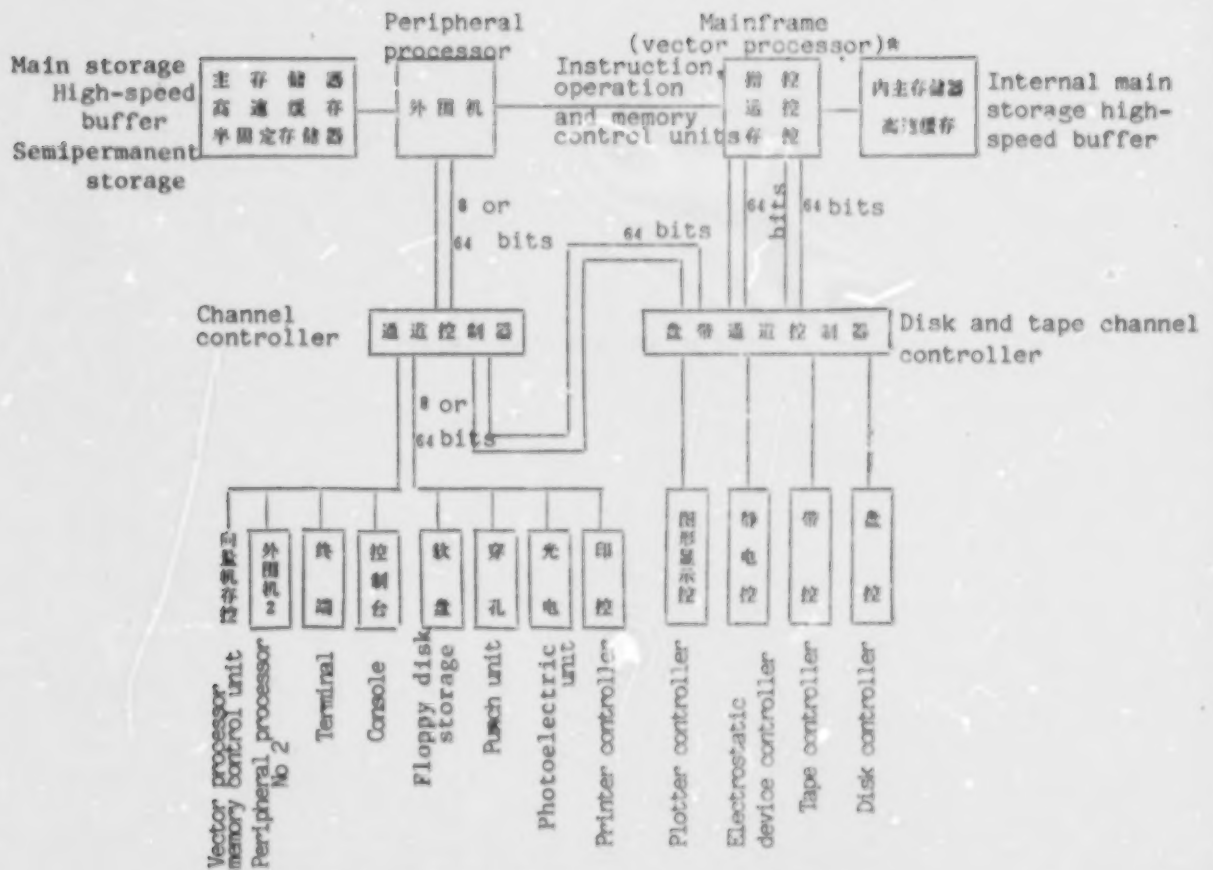


Figure 2. The "757" System Flowchart

(*The mainframe also includes the ALU)



Figure 3. Vector Processor of the "757" Large Computer (Mainframe)



Figure 4. Peripheral Devices of the "757" Large Computer

making it possible to expand the capability of the main storage to three to four times that of conventional high-speed pipelined machines with equal efficiency. Architecturally, it employs three main control elements, namely the instruction control unit, the operation unit and the memory control unit. It also utilizes a high degree of overlap between the ALU [arithmetic-logic unit] and memory components. The 16 main memory units are parallel-interleaved. The power of the instruction set is quite considerable. Thus, it was possible to convert a conventionally-designed 2-MIPS computer's low-speed components and modules to build the large 10-MIPS high-speed "757" machine.

The hardware system includes a vector processor, a peripheral processor, and peripheral devices. The vector processor conducts vector processing in a single-pipeline structure, using the crossbar in-process [4912 2897 0502 1562] method. This is rather efficient for large-scale scientific and engineering computations involving mainly parallel calculations; the average operating speed is 10 MIPS. The average speed for scalar computation is 2.8 MIPS. The vector word length and instruction word length are both 64 bits. Data types include full word floating point number, half word floating point number, double word floating point number, signed integers, and unsigned integers (including 1-, 2-, and 4-byte integers). There are a total of 107 instructions, of which 97 are user-accessible, while the other 10 are for system use.

The vector processor consists of an instruction control unit, an operation control unit, a memory control unit and a main memory system. The three controllers use Chinese-made ECL [emitter-coupled logic] medium-scale and small-scale integrated circuits [MSI, SSI], with an average level of delay time $t_d \leq 4$ ns and a clock frequency of 8.2 MHz. The superhigh-speed buffer memory uses Chinese-made LSI [large-scale integration] circuits and has an access cycle of 100 ns and a read time of 30 ns. The main storage has a capacity of 520,000 words 72 bits long (including an 8-bit check code). A cycle is 1.5 μ s, and the fetch time is 800 ns. The system consists of 16 individual units (plus 2 backup units), and its maximum access speed is 8.2 million words per second in modulo-16 operation. Two hot-standby units allow operator-initiated or automatic switchover. It can also be switched over partially. The system in degraded operation can function in either modulo-8 plus modulo-4 or single modulo-8.

The peripheral processor is a medium-size computer. Its word length is 64 bits and it operates in the fixed-point mode with a main clock frequency of 2.5 MHz. Its average operating speed is 500,000 operations per second. It runs primarily operating system and compiler system programs. It consists of a central processor, main storage, semipermanent storage (with capacity of 64K and a word length of 65 bits) and a channel controller. It has an internal memory of 64K with a word length of 64 bits plus an 8-bit check code. The channel controller has 32 channels. There are 45 peripheral devices of 9 types. They include magnetic disk drives, magnetic tape drives, printers, photoelectric input units, punch output units, electrostatic printers, keyboard displays, graphic displays, and floppy disk inputs and outputs.

The peripheral processor handles all language compilations, input and output data processing, management of the peripheral devices, and most of the system management. It relieves the mainframe of a large amount of time-consuming, low-efficiency tasks so that it can concentrate on running user programs, thus assuring that the high-speed operating capabilities of the vector processor will be fully utilized and ensuring the problem-solving efficiency of the entire system.

In order to increase system reliability, computation speed, and efficiency, the "757" machine not only has pooled the successful experience acquired in past development of many large- and medium-sized computers, but in addition referenced certain then-advanced international technologies as well, so that the machine has many unique characteristics in both hardware and software engineering.

The logic design of the mainframe's instruction set, arithmetic unit, and memory control components all have used some new algorithms and control methods. For example, the instruction control unit uses a control method combining beat and overlap, as well as high-speed instruction buffer technique; the ALU uses iterative division, multidigit parallel multiplication, and direct-code [i.e. not complement] addition method; the memory control unit uses the Hamming code error correction technique and modulo-16 cross access and dual backup memory unit design methods. These features make the design of the three control units considerably more sophisticated than in previous models and are a major factor enabling the machine to operate reliably at 10 MIPS.

The main memory circuit design of the vector processor has been improved by lowering the utility voltage and decreasing component power consumption. In addition, the Institute personnel visited the plants and worked with them to improve the quality of components, so that the reliability indexes of individual memory units have been improved markedly. The average length of stable operation has been increased from 100 hours to more than 500 hours (excluding Hamming code checks).

The main work on the peripheral processor was to focus on improving reliability and convenience of operation. Because painstaking work was done on logic design and engineering realization, it was the first section of the system on which work was completed. In the first test, the longest period of fault-free operation was 418 hours.

The "757" machine has a total of 45 peripheral devices of 9 types. The total capacity of its magnetic disk storage is 16 million words (a total of 8 units at 2 million words per unit). Some of the disk packs are domestically produced (shown in Figure 5). It is a gratifying step to be able to develop these from scratch, thereby laying the groundwork for future Chinese development of large-capacity disk storage. The magnetic tape storage uses the advanced international CCR [group-coded recording] method. They are superior to existing Chinese-made tape storage in both recording density and error-correcting capabilities. Recording



Figure 5. Removable Disk Pack

density has been increased from 500 bits per inch to 2,500 bits per inch. Others, such as the use of (2,048 x 2,048) bits per frame high-density electrostatic printout device and a microprogram-controlled wide line printer, as well as a color graph plotting output unit and floppy disk input-output units, make the "757" machine with peripheral devices superior to those of previous computers. This is a gratifying change for Chinese-made computer peripherals, which have always been a weak link.

The quality of the power supply affects the reliability of the entire computer. The "757" uses a zero [wugong [3541 1562]] frequency input transformer, which greatly decreases the dimensions of the power supply, saves energy, and improves efficiency. The power source to the mainframe's three control units operating in parallel is realized, forming a redundant system, which increases the reliability of the power supply system.

As for mechanical design, the vector processor is laid out in a circular configuration in order to shorten the amount of wiring and increase the speed. In addition, it uses multilayer printed circuit boards, wire wrap, and other new technologies. Standard cabinets are used throughout the machine. A static-pressure parallel short-conduit ventilating system is used, which is simple and easy to operate and gives excellent results.

The 757's software system includes an operating system, vector FORTRAN and a compiler, a mainframe assembly language and assembler, internal function subroutine, a basic graphics package (BCP), and a peripheral processor assembly language and assembler, as well as a diagnostic program, a double-calculation program, etc. The system software totals nearly 20,000 instructions.

The "757" system software not only has considered the entire system's high degree of pipelined overlap and vector operation, but also every effort is made to assure reliability and ease of operation for the user.

The operating system was initiated primarily for reliability and high efficiency and sets up preferential tasks; as such its scope is in the middle. It is a multiprocessing batch-oriented operating system. It allows 31

programs to be put in the backup state and 16 programs in the executing state; 9 programs can be run in the vector processor and 2 in the peripheral processor [?]. The system can take protective measures when errors arise during operation; these include an occasional jitter in double-calculations, coordinate double-calculation diagnosis, and continuation of operation from breakpoint. The system has a monitor and a timer (compatible with the M-170), billing and other accounting functions; document security is assured through a variety of passwords.

The "757" vector FORTRAN language is the binding characteristic of the vector processor. Its design is based on the new international standard FORTRAN-77. It has been suitably expanded in terms of data types, vector components and its operational phase. In addition, the "757" vector FORTRAN is upwardly compatible with FORTRAN 66. Because a necessary expansion has been carried out, programs written in vector FORTRAN can now make better use of parallel vector processing to realize high-speed calculations.

The system software also provides 18 basic internal functions and 92 standard subroutines. It includes three types of numbers--single precision, double precision, and complex numbers.

The merits of the basic graphics package are device-independence and ease of use. In connection with the 757 mission, software development involved program design tools, R&D of program structure and methods, and establishment of a primarily processing-oriented tool language, EML, which was used to write all of the vector FORTRAN assembly programs.

In order to increase the efficiency and reliability of the "757," a special mainframe diagnostic system was designed. It uses the peripheral processor to carry out diagnostics for the mainframe. The diagnostic system has error detection, alarm and retry capabilities. Diagnosis is performed automatically, and for transient faults the system automatically tests for reexecutability by trying to reexecute as many as seven times. The extent of overlay varies in the different component units but is generally 50 to 90 percent.

In the case of permanent faults, the system uses both automatic and manual diagnosis. The automatic card identification feature can generally determine the location of a fault to within a few cards or even to one specific card. The vector processor's memory can automatically correct faults, identify malfunctioning boards or perform switchovers, depending on the nature of the fault.

The "757" is Chinese-designed and based on Chinese technical capabilities, and uses domestically-produced components (the system uses LSI, MSI, and SSI integrated circuits and has over 300,000 parts and components of more than 40 types). As described above, both the entire system and the hardware and software separately were subjected to painstaking design and stringent engineering realization. In order to assure high quality and to speed up progress on the project, we used computer-aided design (CAD) virtually throughout. We used earlier Chinese-developed computers to design

this large 10-MIPS computer. In order to test the stability and reliability of the system, before it was submitted for state evaluation we performed 15 consecutive days of continuous reliability testing. The 20 test problems which were used were rather representative and fairly difficult. The results indicated that processing the test problems had yielded correct results; the average period of stable operation of the system (including mainframe, peripheral processor and peripheral devices) was found to be 120 hours, the system availability was 99.8 percent, and the longest single period between failures was 205 hours, 40 minutes. By domestic standards these figures are all advanced achievements for large general-purpose computers.

The successful development of the 757 was the result of self-reliance and large-scale coordination. Thirty departments and localities and more than 80 units nationwide took part in the process, and all made a maximum effort. The participation of this large number of departments and units indicates the immense scale of the "757" development process. This gives us the gratifying realization that the consequences of the successful development of the "757" are not only embodied in the computer itself, but also are present in a series of new processes, technologies, and products that grew out of the project. Thus a certain stimulus has been given to the improvement of China's computer development standards and to the further development of computer science and technology.

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SYSTEM ARCHITECTURE OF 757 VECTOR COMPUTER

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 2, 1984 pp 7-16

[Article by Yang Shufan [2799 2885 5400], Institute of Computing Technology, Chinese Academy of Sciences (CAS)]

[Text] The system architecture, main performance characteristics, technical specifications and design characteristics of the "757" vector machine are surveyed. In hardware, attention is devoted to the method of making thorough use of the vector machine's lengthwise and crosswise processing capabilities and overcoming collisions, the fatal problem in pipelined machines; to the method of dealing with speed allocation among the three control units of the vector machine; and particularly to the method of handling supply-demand conflicts between the high-speed central processor and low-speed magnetic core storage.

I. Overview

The 757 computer system is a large general-purpose computer oriented to vector computation. It consists of a vector machine, a peripheral processor and various peripheral devices, as well as software. The vector machine has a parallel overlapped single-pipeline structure and is constructed entirely of Chinese-made components. The present article focuses on the hardware structure of the vector machine.

1. Main Characteristics of the Vector Machine

Word length: 64 bits (including operand and instruction). Main memory capacity: 512 K words, word length 64 bits, with 8 additional check bits. The operand fetch address can be refined to the byte level. Main clock frequency: 8.2 MHz. Speed: in problems suited to parallel computation the machine operates at high or medium efficiency and the average computation speed is about 10 MIPS, while for scalar operations the system is in a low-efficiency state and the average speed is 2.8 MIPS.

2. Technical Specifications

A. Components: The machine uses exclusively Chinese-made medium- and small-scale integrated circuits of the ECL [emitter-coupled logic] type. The circuit series includes 10 production types: besides the 5 types of gate circuits, 2 model D flip-flops, a 4-bit half adder, an 8-bit shift register, and a semiconductor memory unit.

Speed characteristics: Gates and half-adders, average gate delay $t_{pd} \leq 4$ ns; flip-flops, $t_{pd} \leq 6$ ns; shift register, $t_{pd} \leq 10$ ns. Semiconductor memory: cycle time $T \leq 100$ ns, readout time, $t_d \leq 40$ ns; average failure rate: 3×10^{-8} (statistics for January-August 1983).

B. Main Memory: Uses magnetic core storage. Access cycle $T \leq 1,500$ ns, read time $t_d \leq 800$ ns. Each memory unit has a capacity of 32K words with a word length of 64 + 8 bits. The main memory system consists of 18 units, of which 2 are on warm standby and can switch over automatically. When necessary the system can automatically cut-off a part of the memory unit and go into degraded operation. The system can operate in modulo-16, modulo-8 + modulo-4, and modulo-8 form.

C. Pulse System: The system uses a single-clock synchronous pulse system with a principal frequency of 8.2 MHz and a pulse width of 50 to 60 ns.

D. Interconnection Technique: Multilevel printed circuits (including cards and boards) and twisted pairlines. System impedance 90 ohms.

E. Vector Machine Layout: (Other than the main memory) circular arrangement, consisting of 11 racks, each with 10 printed circuit boards; a total of 107 circuit boards and 1,119 cards with about 45,000 integrated circuits are used.

F. Cooling Method: Air cooled. Incoming air temperature $17 \pm 1^\circ\text{C}$, relative humidity, 40 to 60 percent. Module surface temperature $< 55^\circ\text{C}$, maximum temperature difference between modules $< 30^\circ\text{C}$.

3. System Reliability Provisions

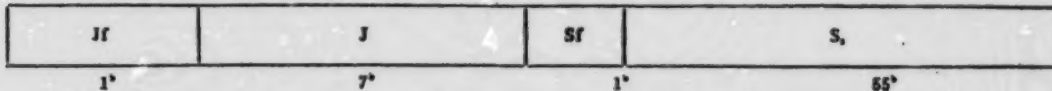
The mainframe's three control units use parity checks, backup equipment diagnostics, and a double-calculation system. The double-calculation can be made at the instruction execution level or the register level. Fault diagnosis and location is accurate to within 1-3 cards; the main memory uses an odd-weighted code error detection system, while the two external backup units can perform operator-initiated or automatic switchovers. It is estimated that adoption of these measures can increase the relative reliability of main memory by more than 3.5 times. The system can also cut off a unit, and in the degraded mode it can function in modulo-8 + modulo 4 or simple modulo-8 form. These capabilities are implemented by the memory control unit.

II. Data and Instruction Formats

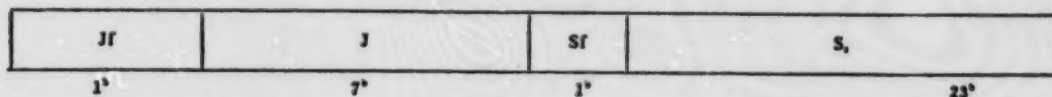
1. Data Formats

Floating point numbers: It consists of the characteristic sign (Jf), the characteristic code (J), the number sign (Sf), and the mantissa (Ss). The characteristic is expressed in complement form and the mantissa in basic form, and machine language zero is expressed by "0". There are three types of floating point:

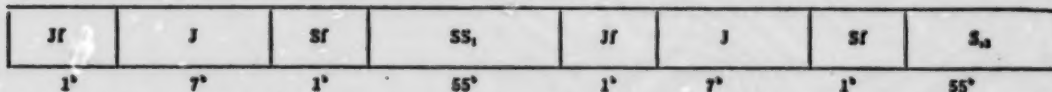
- 1) full word floating point (64 bits), occupies one memory cell.



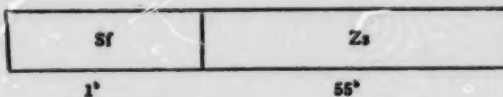
- 2) half word floating point (32 bits), occupies half a memory cell.



- 3) double word floating point (128 bits), occupies two memory cells. The two cells have the same characteristic and number sign. S_{S1} is the high-order part of the mantissa, and S_{S2} the low-order part.

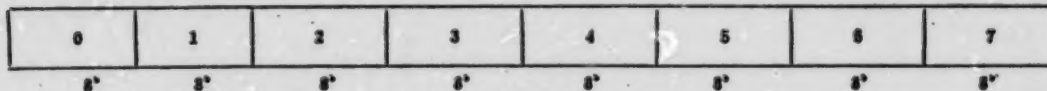


Signed integers: These are in direct code, consisting of 56 bits including sign.

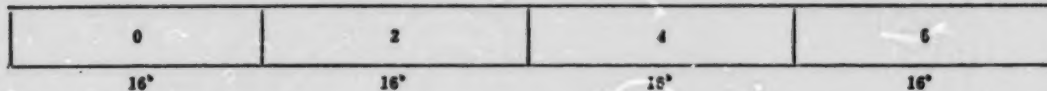


Unsigned integers: There are three types, stored in main memory as follows:

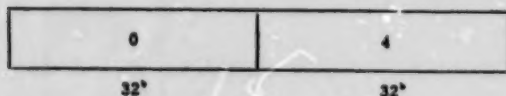
- 1) one-byte integers (8 bits), with each memory cell containing eight integers;



- 2) two-byte integers (16 bits), with each memory cell containing 4 integers; and



3) four-byte integers (32 bits), with each cell containing 2 integers.



In addition there are 1-, 2-, and 4-byte and full and double-word length codes, number codes, and bits.

2. Instruction format: There are 97 user-accessible instructions and 10 system instructions. The user instructions are of two types:

Operation instructions (77), with 4-address format:

T_1	T_0	Q	$\neg$	K	A'	B'	C'	dt	!	d	B_z	B
1	1	7	1	4	5	7	6	3	1	19	4	5

These include: Q (opcode, 7 bits); T_B (vector-scalar flag, when $T_B = 1$ indicates a scalar instruction); T_Q (operand fetch flag, when $T_Q = 1$ indicates fetch from internal storage, and when $T_Q = 0$ indicates transfer to main storage); A' , B' , and C' (indicate vector-scalar or vector-scalar accumulator and specify the source operand and target accumulator address); K (indicates control vector or control scalar); $\neg$ (indicates the use of the base-minus-one's complement of (K) for control).

If we define: $(X')::=(D')\Rightarrow A'|(D')$, $Z'::=(C')\Rightarrow D'|D'$, then the operation instruction can be described as follows: $(X')Q(B')\Rightarrow Z'$

Addressing Mode: A main storage address D' is described by the combination T_B , dt, d, !, B_z , and B; the address may refer to a byte. When $d = 0$, $b = b_0$, internal storage is not accessed and the instruction is an accumulator-type instruction.

Element dt is the byte flag, which indicates the type of data to be fetched; ! is the successor symbol; d is the formal address (19 bits); B is the index and refers to b_{0-31} , with a word length of $(B) = 22$ bits; B_z is the increment, and when B_{z0-11} is referred to, (B_zi) is the equidistant vector increment, when B_{z12-15} is referred to, this refers to the indirect address register (q_{0-3} or q_{0-3}) where (q) is 22 bits long.

For equidistantly stored data:

$$\begin{aligned}
 \text{scalar } D' &= d + (B) \\
 \text{vector } D_0 &= D' + 0 \cdot (B_z) \\
 D_1 &= D' + 1 \cdot (B_z) \\
 &\vdots \\
 D_{\ell-1} &= D' + (\ell-1) \cdot (B_z)
 \end{aligned}$$

For indirect addressing:

$$\begin{aligned} D' &= d + (B) \\ \text{scalar } \vec{D} &= D' + (q_1) \\ \text{vector } \vec{D} &= D' + (q_l) \\ 1 &\leq l \leq 16 \end{aligned}$$

Once the logical address D is found, the real address is determined from the page table.

Control instructions (20), including jumps, loops, index operations, index transfers and the like. The instruction format is:

T_1	T_2	Q		m_1	m_2	N		d	BZ	B
1	1	7	3	7	7	6	4	19	4	5

Here T_1 is the instruction dispatch flag. For jump instructions, T_1 controls whether or not the subsequent instruction should continue to be dispatched to the next instruction register (ZH). T_2 is the locator flag, which is only used in switch instructions. In loop segments with fewer than 64 instructions, T_2 can be used to control loop execution in ZH. The reason for providing T_1 and T_2 is to minimize transfers from internal memory and to increase the efficiency of ZH. Q is the opcode (m_1 , m_2 , and N indicate B , BZ , KB_{0-15} , JN , and J_{Dt} , the registers involved in instruction control, in order to carry out such operations as jumps, index operation control, and index transfer.

III. The 757's System Architecture and Features

Architecture of the "757" Machine

The 757's vectormachine, peripheral processor, and peripheral devices are shown in Figure 1.

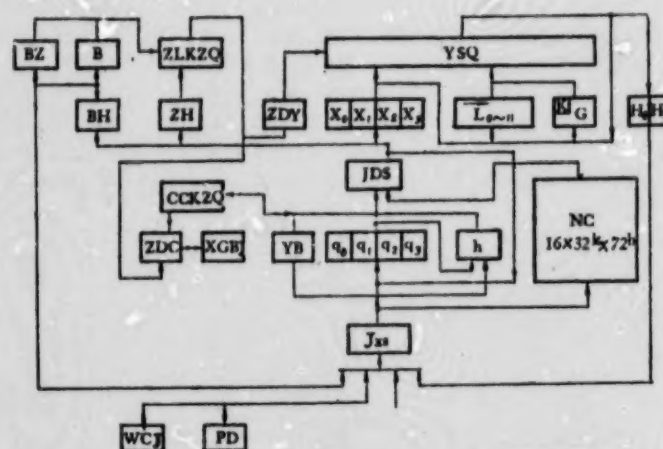


Figure 1. Block Diagram of the 757 Architecture

The peripheral processor has a word length of 64 bits and carries out floating point operations. It has a main clock speed of 2.5 MHz and an average speed of 500,000 Hz. Its internal memory capacity is 64,000 words. The semifixed storage capacity is 64,000 words. The peripheral machine runs primarily system programs, while the mainframe (vector machine) runs primarily system applications programs. There are two channels connecting the mainframe and peripheral processor: one is a communication channel, using the interrupt method, by which they exchange control information; the other is a direct batch transmission channel in the time sharing mode. Information transfer between the mainframe and the disks, tapes, electrostatic printers and graph plotters may also be in the time-sharing mode. The disk resources are shared by the main and auxiliary machines. All peripheral devices operate under the control of the peripheral processor.

The mainframe (vector machine) has a single pipeline structure and basically belongs to the register-register class. The mainframe consists of the instruction control unit (ZK), the operation control unit (YK), the memory control unit (CK), and main memory (NC). These are described below:

1. The Instruction Control Unit (ZK): The ZK consists of the instruction buffer register (ZH) ($4 \times 16 \times 64$ bits), index registers B (32×22 bits), increment registers 13Z (32×22 bits), the address ALU, general purpose registers, and an interrupt processor. Its functions are to analyze instructions, execute operation or access instructions, then transfer them to YK or CK; to execute control instructions; and to respond to interrupts.

2. The Operation Control Unit (YK): This consists of an ALU, accumulators (including vector accumulators L_{0-11} and scalar accumulators L_{0-11}) with capacities of $12 \times 16 \times (64 + 8)$ bits, high-speed scalar registers G ($32 \times (64 + 8)$ bits), look-ahead operand fetch stack X_{0-3} ($4 \times 16 \times 72$ bits), look-behind operand store stack H_{0-1} ($2 \times 16 \times 65$ bits), operation control unit instruction stack ZDY (16×75 bits) and the requisite control circuitry; it carries out arithmetical and logical operations.

3. The Memory Control Unit (CK): The memory control unit consists of the storage control stack ZDC (16×87 bits), look-behind wait station JH_{0-1} (2×67 bits), a collision processor, auxiliary machine interface buffer register WH (16×65 bits), 2 sets of disk and tape interface buffer registers ($2 \times 2 \times 16 \times 65$ bits), indirect address register q_{0-3} ($4 \times 16 \times 23$ bits), compress and restore vector registers (2×16 bits), page table registers (128×14 bits), an address adder, the main storage checking and correction unit, and memory unit switchover and cut-off circuitry.

It handles collisions, time-shared queuing, address processing, page mapping, memory protection, data compression and restoration, byte control, memory correction, cut-off units, switchovers, etc.

4. Main Storage (NC): The main storage consists of 18 core storage units (2 of which are backup units). Each unit has a capacity of $32K \times 72$ bits and an access cycle of 1,500 ns; storage operation can be modulo 16, $8 + 4$, or 8.

IV. Architectural Characteristics of the 757 Vector Machine

The basic characteristic of the 757 vector machine is that it introduces vector computations in a single-pipeline architecture and uses the lengthwise and crosswise method of vector processing. This decreases the amount of instruction handling tenfold, greatly decreases the number of conditional jumps, greatly reduces the number of collisions between operations, decreases memory access requirements, and makes memory access more uniform, thus fundamentally improving pipelining effectiveness.

In order to take full advantage of parallel operation and pipelining in the 757, not only will the user have to make a continuing effort to develop parallel-oriented algorithms and write suitable programs, but in addition it will be necessary to design hardware structures suited to computers of this type. Below we describe the system architecture of the 757, primarily in terms of hardware structure design.

1. Use of a Mainframe-and-Auxiliary Computer System With Distribution of Capabilities: When solving problems in a computer system, not only applications programs, but also system programs (including the operating system, the compiler system and the like) must be run. These two types of programs differ greatly in terms of program structure, data structure, relative importance of different types of instructions in them, and operating environment. The systems programs primarily perform fixed-point scalar operations, have a high proportion of conditional jumps, and are subject to frequent interruptions, so that programs and operating environment of this type are not suited to operation on a highly overlapped, primarily vector-oriented pipelined machine. This is why the two-machine architecture is used in the 757. The auxiliary machine runs primarily system programs, while the mainframe runs primarily applications programs. This utilizes the strong points of each machine and makes thorough use of the characteristics of the vector machine.

2. The vector machine has a wide range of vector processing methods, which expand the range of vector computations and thus the area in which the machine can be used with high to medium efficiency.

(1) The operation instruction vector and scalar instruction formats within the same instruction format; a four-address format and a multi-accumulator architecture are used to decrease the number of both memory accesses and auxiliary instructions.

(2) For convenience in writing programs for lengthwise and crosswise vector processing, the instructions include vector loop switching instructions, vector subgroup loop switching instructions, and other instructions geared to vector processing.

(3) The control vectors $\vec{k}$, $\vec{h}$, and $\vec{q}$ are provided. The operation control vector $\vec{k}$ is used to control whether or not an operation is executed, which can greatly decrease branching. The compression and restoration vector $\vec{h}$

controls main memory read and write. In the processing of sparse matrices it can greatly decrease the number of memory cells used and speed up memory access. The indirect address control vector $\vec{q}$ can form a group of noncontinuous or random address strings, which is helpful in processing sparse matrices.

(4) The spacing of data stored in memory can be arbitrarily chosen, affording high efficiency in alternation of direction in the processing of multi-dimensional vectors.

3. Highly Parallel, Overlapped Pipeline Architecture: In executing programs, the vector machine uses a 16-segment lengthwise-crosswise processing technique for vectors. All major units of the machine operate in a completely overlapped, parallel state, and also in a highly pipelined fashion. For example, the ALU can produce one floating-point addition result per clock unit, while the storage controller can read or write one datum in each clock unit. The instruction and data flows in the machine are shown in Figure 2.

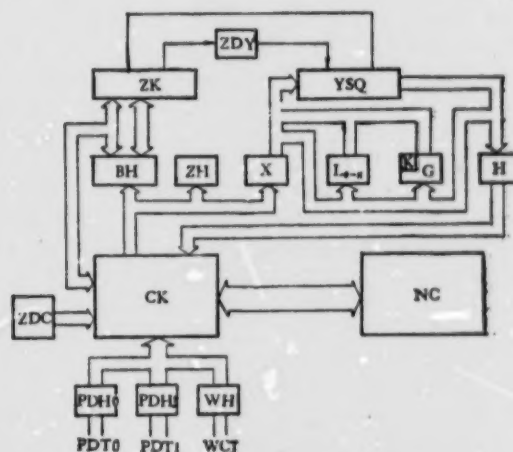


Figure 2. Information Flows in the Vector Machine

Pipelining is an effective method of high-speed operation; but in order to make full use of its capabilities, not only pipelines within all individual units, but also the parallel overlapped pipelines between the units, must be kept moving freely. Tests on seven different problem types show that sequential operating states (i.e. with the three controllers pipelined, but with ZK, YK, and CK operating serially) the machine as a whole is slower than with parallel overlap by a ratio of 1 to 1.38. The main defect influencing parallel overlapping of the three controllers is collisions. The smoothness of pipelined operation is seriously affected by collisions in conditional jumps, collisions in the processing of memory data into internal store addresses by the ALU, operation collisions, index collisions, fetch and store collisions, and memory unit collisions, as well as the collisions produced by lack of speed matching between the various machine units and between the three controllers and memory. These problems are dealt with in the following main ways.

- (1) Provision of the operation control vector $\vec{K}$, which reduces conditional jumps.
 - (2) Provision of the address buffer register group BH_{0-3} ($4 \times 16 \times 23$ bits), which makes possible batch processing of data from memory into addresses by the ALU; these are transferred in a group to BH, from which the instruction controller accesses the needed information. There are four BH registers, which greatly decreases interference with the instruction stream.
 - (3) Processing of the object program by the peripheral processor: The vector machine does not process instructions, which alleviates collision between instruction fetch and data transfer channels.
 - (4) Use of the operating system to handle collisions between the peripheral processor channels, disk and tape channels, and mainframe internal memory access channels.
 - (5) Data fetch and store collisions: In the vector machine, the main information flow is data flow, accounting for the great majority of overall information flow. When operations are transferred from main memory to the operation controller via the storage controller and the processing results are transferred back to storage controller, the overall path is very long. If data fetching and storage are carried out in a program-specified sequence, the speed of the main machine is seriously affected. Therefore collision discrimination must be carried out between all fetch and store address spaces; where there is no conflict for address spaces, the data can be prefetched. Tests on the seven problem types indicate that this prefetch processing increases overall machine speed by 63 percent compared with processing in program sequence.
4. Speed Matching of the Three Control Units. Because the mainframe is primarily vector-oriented, when executing vector instructions the amount of work by the instruction control unit is decreased to $1/10 \sim 1/20$; according to analysis and system simulation, for problems involving primarily parallel processing the effective operating time of the instruction control unit is only 12.5 percent. But in order to provide for problems involving principally scalar computations or serial computations, the instruction controller is designed to process one instruction in an average of 3 to 4 beats, so that it can process from 2.5 to 3 million instructions per second. Therefore increasing the data transfer speed of YSQ and storage as much as possible and matching their speeds as closely as possible constitute the key to increasing overall speed. The memory is designed for a maximum flow rate of 1 byte access per beat while the ALU is designed for a speed of one operation per beat (with the exception of multiplication, division and certain special instructions). For example, comparison of characteristics and normalization in floating point addition both require one beat and partial operations are eliminated, which makes the pipelines more uniform. YSQ has a multibit fast multiplication algorithm and iterative division, which increase its processing speed. In order to match the speeds of the three controllers, their interfaces are provided with buffer stacks, which, in brief, are designed as follows:

(1) In order to make the data flows uniform, interference with main storage for instruction fetch has been minimized, and the instruction controller is provided with instruction buffer registers ZH ($4 \times 16 \times 64$): more than 96 percent of loop segments can be executed in ZH. Instructions can be transferred out of memory in groups with high efficiency (16 at a time), radically decreasing the frequency of instruction fetches from the main store. ZH is divided into four components and operates modulo 4. Instruction processing and instruction transfers can be entirely overlapped. Tests of the seven problem types indicate that without ZH, the speed of the main machine would be decreased by a ratio of 1 to 1.15.

(2) In order to increase the parallelism of ZK, YK, and CK, unit YK and the storage controller are provided with instruction stacks ZDY and ZDC (each with a capacity of 16 instructions).

(3) In order to keep the data flow uniform and to overlap the operation of all machine units and memory accesses, the following are provided:

--look-ahead fetch stacks X_{0-3} ($4 \times 16 \times 72$ bits);

--look-behind transfer stacks H_{0-1} ($2 \times 16 \times 65$ bits);

--index buffer stacks BH_{0-3} ($4 \times 16 \times 23$ bits);

--a peripheral processor channel data buffer stack WH ($1 \times 16 \times 65$ bits);
and

--disk and tape channel data buffer stacks PH_{0-1} ($2 \times 2 \times 16 \times 65$ bits).

5. Speed Matching Between Main Storage and Central Processor. The mainframe's three control units use high-speed ECL circuitry and, on average, process data at a speed of one operation per beat (approximately 100 ns), while owing to current technological limitations, the main storage uses low-speed magnetic core storage and has an access cycle of 1,500 ns. This is obviously a major conflict, and represents the key factor affecting overall machine speed. The following steps were taken to resolve it.

(1) Decreasing information flow to and from the main store by decreasing the system's memory access requirements:

a. Because lengthwise-crosswise processing of vectors is performed, it becomes possible to use multiple accumulators; the instruction controller is provided with 12 vector (or scalar) accumulators (Z_{0-11}) and a high-speed scalar buffer memory G (32 words). In this way, intermediate results and repeatedly used contents can be transferred to L and G, respectively, which considerably decreases the number of memory accesses. This decreases memory accesses by two-thirds to three-fourths or even more compared with a purely lengthwise processing machine (such as the STAR-100).

b. In order to decrease demands on memory and avoid a great decrease in speed, the 757 vector machine does not use the virtual storage dispatching method, but instead uses batch pretransfer. Because the main storage has

sufficiently large capacity and the system uses simple multiprogramming geared to one large problem, this dispatching method assures high speed and greatly simplifies the logic structure of both software and hardware.

c. Because data can be fetched and stored under the control of the compression and restoration vector $\vec{h}$, and the data can be fetched in byte-wise fashion, the amount of memory space used for sparse matrices and byte operations is decreased and the number of accesses to main storage is greatly reduced, thus increasing access speed.

d. Provision of the instruction buffer registers ZH decreases the number of main storage accesses for memory fetch to 1 percent or less.

(2) Increasing the access speed of the memory system: Even with the measures described above, the system still requires a nearly 1-to-1 memory access speed. In other words, each time the ALU carries out one operation, an average of one memory access is required. If the ALU's maximum processing speed is one operation per beat then a maximum memory speed of nearly one access per beat will be required. But because the core storage access cycle is $T = 1,500 \text{ ns}$, meeting this requirement requires a modular interleaved parallel memory system. The main requirements for such a parallel memory system are an access rate of close to 1 access per beat (if the main frequency is 10 MHz, then one beat = 100 ns), and no conflict between units. Let us discuss these conditions.

a. For storage of an "equidistant" vector $\vec{A}$ (i.e., a vector whose increment Δ is a constant, if we designate the number of internal storage units in the parallel memory system as m , the access cycle for each memory unit by T (with the clock period P as a unit, $1P = 100 \text{ ns}$), and the address increment between vector components as Δ , we obtain the following results:

① When fetching or storing one vector the maximum number of storage units that can be accessed is:

$$m' = m / (\Delta, m)$$

where (Δ, m) is the greatest common factor of Δ and m .

② When accessing one vector in each storage cycle, if the vector length is $\ell > m / (\Delta, m)$, the maximum latency time is

$$t_A = \begin{cases} 0, & m / (\Delta, m) \geq T \\ T - m / (\Delta, m), & m / (\Delta, m) < T \end{cases} \quad (1)$$

It is evident from equation (1) that for an "equidistant" vector the condition must be met for a collision-free parallel storage system is $m / (\Delta, m) \geq T$.

Because Δ is an arbitrary integer, this condition can be met only under certain conditions. Suppose $\Delta = 0, 1, 2, Km-1$, (where K is an integer). If Δ is uniformly distributed on the interval from 0 to $Km-1$, then the average latency time is

$$t_A = \left(\sum_{\Delta=0}^{Km-1} t_{\Delta} \right) / Km$$

Because for all $K = 0, 1, 2,$

$$(\Delta, m) = (\Delta + Km, m)$$

therefore

$$t_A = \left(K \sum_{\Delta=0}^{m-1} t_{\Delta} \right) / Km = \sum_{\Delta=0}^{m-1} t_{\Delta} / m \quad (2)$$

Actually Δ is not uniformly distributed. For example, in multiplication of a matrix by a scalar,

$$\begin{bmatrix} a_{11} & \dots & a_{1n} \\ \vdots & & \vdots \\ a_{n1} & \dots & a_{nn} \end{bmatrix} \times \begin{bmatrix} b_1 \\ \vdots \\ b_n \end{bmatrix}$$

If the elements of matrix A are stored row by row, and if vector $\vec{b}$ is a sequential vector, then for this operation $\Delta \equiv 1$. If we assume that the distribution probability for $\Delta = 1$ is 75 percent, then equation (2) can be revised to

$$\begin{aligned} \bar{t}_A &= t_1 \times 75\% + \left(\sum_{\Delta=0}^{Km-1} t_{\Delta} \right) / Km \times 25\% \\ &= t_1 \times 75\% + \sum_{\Delta=0}^{m-1} t_{\Delta} / m \end{aligned} \quad (3)$$

The revised values can be read from line t_B in Table 1.

When accessing vector $\vec{B}$ after accessing vector $\vec{A}$, because the addresses are not continuous and the resultant unit collisions are random, the average latency time t_{AB} within each access cycle is

$$t_{AB} = \begin{cases} T(T-1)/2m & m \geq T \\ T - \frac{m+1}{2} & m < T \end{cases} \quad (4)$$

Because the 757 vector machine uses the lengthwise-crosswise processing method, the vector is segmented so that $\ell' = 16$, which is equivalent to an additional latency time of t_{AB}/ℓ' during each access of a component. Because $\ell = 16$, the individual time increments are considerable.

Table 1. Memory System Capabilities (Main frequency = 10 MHz, access cycle 1,500 ns = 15(P))

$t, v \backslash m$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$t_A(P)$	14	13.5	12.67	12.25	10.8	11.5	8.86	9.63	8.22	8.7	4.91	8.58	2.92	5.79	5.2	4.81
$V_A(MW/S)$	0.67	1	1.56	1.83	2.8	2.33	4.1	3.58	4.52	4.2	6.72	4.28	8.05	6.14	6.56	6.79
$t_B(P)$	14	13.25	12.17	11.31	10.2	9.12	8.21	8.06	6.55	5.93	4.23	4.39	2.23	2.20	1.3	1.2
$V_B(MW/S)$	0.67	1.2	1.9	2.4	3.2	3.9	4.5	4.63	5.63	6.1	7.18	7.07	8.5	8.53	9.1	9.2
$t_{AS} \text{ or } t_{scalar}$	14	13.05	13	12.5	12	11.5	11	10.5	10	9.5	9	8.5	8	7.5	7	6.56
$V(MW/S)$	0.7	1	1.34	1.94	2.70	3.44	5.06	4.8	5.22	5.65	6.80	6.70	8.18	8.22	8.84	8.92
$t, v \backslash m$	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
$t_A(P)$	0.82	5.83	0.74	5.45	4.09	3.05	0.61	5.46	2.16	1.96	2.74	3.68	0.48	4.03	0.45	2.75
$V_A(MW/S)$	9.41	6.11	9.51	6.37	7.27	7.97	9.59	6.36	8.56	8.67	8.17	7.55	9.68	7.13	9.70	8.17
$t_B(P)$	0.21	1.46	0.18	1.36	1.02	0.76	0.15	1.37	0.54	0.49	0.68	0.92	0.12	1.01	0.11	0.70
$V_B(MW/S)$	9.86	9.02	9.88	9.1	9.32	9.5	9.9	9.09	9.64	9.67	9.6	9.4	9.92	9.32	9.93	9.6
$t_{AS} \text{ or } t_{scalar}$	6.18	5.83	5.53	5.25	5	4.77	4.57	4.38	4.2	4.04	3.89	3.75	3.62	3.5	3.39	3.28
$V(MW/S)$	9.6	8.8	9.65	8.87	9.1	9.3	9.7	8.9	9.46	9.5	9.38	9.23	9.77	9.18	9.8	9.4

In the case of scalars or "nonequidistant" vectors ($\Delta \neq$ constants such as indirect address vectors), the latency time resulting from storage unit collisions is likewise random, and the average latency time is the same as in equation (4):

$$t_{\text{scalar}} = \begin{cases} T(T-1)/2m & m \geq T \\ T-(m+1)/2 & m < T \end{cases} \quad (6)$$

The average access speed of a parallel memory system for an "equidistant" vector is:

$$V_1 = V_{\text{max}} \cdot \frac{T-\bar{t}}{T} \quad (7)$$

V_{max} is the maximum speed of the system (i.e. the speed when there is no collision between units and there is one access per beat).

The average access speed for a scalar is

$$V_2 = 1/t_{\text{scalar}} \times 10^6 \text{ words per second} \quad (8)$$

If $T = 1,500$ ns, the principal frequency is 10 MHz, and $1P = 100$ ns, then we have $T = 15P$. Substituting this value into equations (2), (3), (6), (7) and (8), and making the calculations for $m = 1, 2, 3, \dots, 32$, we obtain Table 1 and Curve 1 of Figure 3.

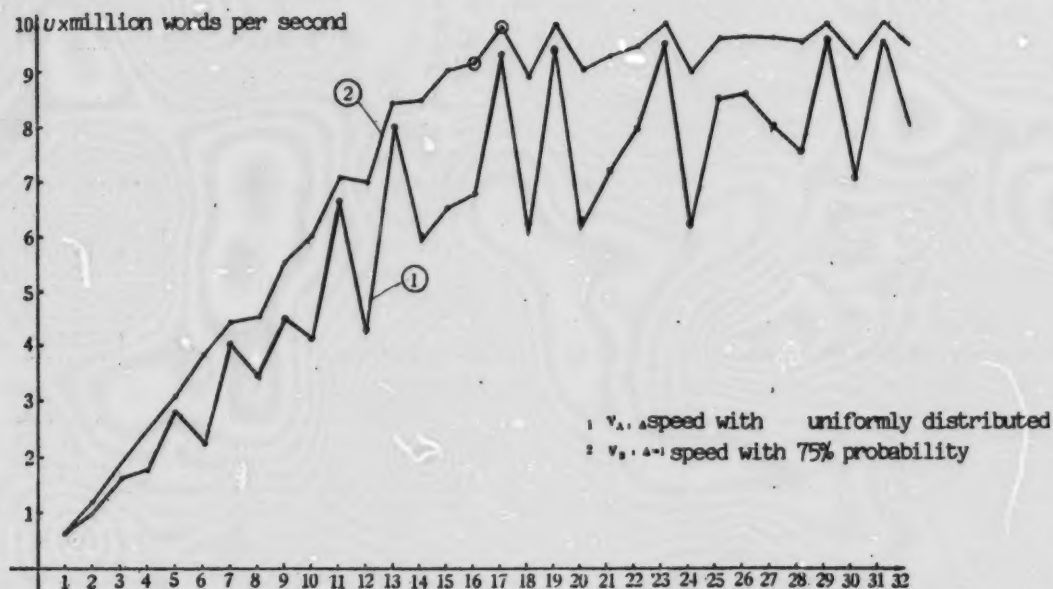


Figure 3. Memory System Capability, Main Frequency = 10 MHz, Access Cycle 1,500 ns

It is evident from equation (1) that for accessing an "equidistant" vector, in order to obtain a maximum speed of 1 byte per beat, we must meet the condition $m/(\Delta, m) \geq T$.

In the mainframe machine of the 757 vector machine $T = 15P$, so that the number of units m must be greater than 15. This is clear from Table 1 and Curve 1 of Figure 3. In addition, it is apparent that prime modulus numbers greater than 15, i.e., 17, 19, 23, 27, and 31 give a rather high-access speed. Of these prime moduli, modulo-17 is the most practicable; the other prime number moduli are unsuitable either because of complexity in address mapping or because of problems of memory use efficiency. But because of the factors noted below, the main memory system of the 757 vector machine uses a modulo-16 arrangement for the following reasons:

1. With modulo-17, it requires a rather complex address mapping structure;
2. Equation (4) indicates that when accessing vector $\vec{A}$ followed by vector $\vec{B}$, the additional latency time t_{AB} resulting from the fact that the addresses are not continuous is rather large in the 757 with a 16-segment lengthwise-crosswise processing. It is evident from Table 1 that when $m = 16$, $T_{AB} = 6.56P$. In other words, for every 16 segments accessed an additional 6.56P must be expended. If we use 16 segments, this time problem cannot be solved by using prime-number moduli. But if modulo-16 is used, then altered readout can be used to avoid loss of time T_{AB} . "Altered readout" means that when accessing vector $\vec{A}$ and then vector $\vec{B}$, if some memory unit is not locked, then the first unit that has been locked is accessed, and only after the 16

components have been read is the vector sequence restored in the look-ahead stations; this process increases access speed. The effect of TAB is to decrease the memory system speed of a modulo-17 memory unit from 9.86 million words per second to 7.2 million words per second; since use of altered readout with a modulo-16 system gives a speed of 7.5 million words per second (assuming that the conditions for altered readout are met 40 percent of the time), it is obvious that the latter alternative gives a higher access speed than use of a modulo-17 memory system. Tests on the seven different problem types indicated that the altered readout method increases overall system speed by 13.7 percent.

3. It can be seen from equation (1) that if $m = 16$, when Δ is odd and $m/(\Delta, m) \geq T$ will always apply (when $T = 15P$), then it can be assured that there will be no conflict between units when accessing vector $\vec{A}$, so that a maximum speed $V = 10$ million words per second will be achieved. Under certain conditions the user can satisfy this condition (i.e., that Δ is odd).

The above discussion of hardware design has been sketchy and incomplete because many needed data have not yet been determined, compiled, and analyzed.

Participants in the development of the 757 vector machine's hardware included Lui Qiye [0491 0796 2814], Li Shuyi [2621 2885 1837], Yang Shufan [2799 2885 5400], Xia Shaose [1115 4801 3844], Xu Jun [1776 3182], Shi Guohua [4258 0948 5478], Li Changzi [2621 2490 1316], Luan Yumin [2940 3022 2404], Luo Yinfang [5012 6892 5364], and Xu Kunming [1776 2492 2494].

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HARDWARE ENGINEERING OF 757 VECTOR COMPUTER SYSTEM

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[Text] Abstract. A concise description of the 757's hardware engineering, implementation, and operation is given. This machine is the first to use Chinese-made medium scale integration [MSI] ECL [emitter-coupled logic] integrated circuits, large multilayer printed circuit boards and double connector printed circuit cards, low-impedance twisted pair lines, and long-line matching with three resistors, yielding complete 90-100 ohm impedance matching of the entire system, which minimizes ringing and crosstalk. Testing of small assemblies and more than 3 years' operation of the entire machine have shown that the hardware engineering system is reliable; the state evaluation indicated that the CPU was fault-free for 360 hours.

I. Introduction

The 757 machine is a pipelined vector machine with a speed of 10 million instructions per second. Users suggested many specifications for the machine, and in order to meet these requirements they were carefully taken into account in overall unit design, engineering design, and hardware design. Below we introduce the hardware engineering design.

The specifications for hardware engineering of the 757 which emerged from the overall design were a circuit delay of 4 ns, a logic chain of 17.5 levels, a maximum line length of 2 m, and a master clock frequency of 10 MHz. In order to meet these requirements we had to make the leads as short as possible, increase the degree of integration, and increase reliability. For this purpose, we developed three near-MSI circuits: a double D flip-flop, a quad half-adder, and an 8-bit shift register. In order to decrease lead length and achieve system matching, we used multilayer printed circuit boards and large cards, low-impedance twisted pair lines, single in-line package [sip] resistor networks, and high-frequency mica [?] [duli [3747 4539]]

capacitors. The machine contains 1,092 cards of 338 types, and a total of 57,178 integrated circuits (including backups). To date, the chip reliability is about 10^{-8} . In order to maintain reliable machine capabilities, we used 90-100 ohm impedance matching throughout the system, minimizing ringing and crosstalk.

In order to expose problems before production of the complete machine, we constructed a model unit with a word length of 16 bits, using 879 DIP [dual in-line package] integrated circuits of 10 varieties. These circuits were equivalent to 9,369 gate circuits and were mounted on 2 8-level printed circuit boards and 17 8-level large printed circuit cards, 1 control board, and 2 pairs of conversion plugs. After this model was tested for half a year and had shown no major problems, the complete machine was put into production. The process from board fabrication, card production, and PC board interconnection to the completion of automatic testing of the cards took nearly 2 years.

Because of a stringent effort in the key areas of production, the time required for debugging of the mainframe was greatly shortened; in particular, the process from testing of parts and components on printed circuit boards to the testing of fully assembled boards used automatic coded testing, so that all of the control units (instruction control unit, operation control unit, memory control unit, and ALU) were correctly debugged in less than half a year.

As a result of software debugging, the time required for the machine to objectively reach the testing stage was somewhat more than 2 years; the numbers of integrated circuits failing over the course of 2 years are shown in Figure 1. The two curves in the figure simply indicate how many modules failed in a given time interval. These failures all belong to the early failure type. Analysis indicated that most involved output follower or input terminal failure, in addition to which some were misdiagnosed; the circuit types in which problems were especially common were the shift registers and quad gates. The principal cause was insufficiently strict surface inspection. But shift registers are relatively heavily used in the instruction control unit, and in some places no heat sinks were provided, so that overheating resulted in a somewhat higher failure rate. Another 20 percent included mechanical damage and accidents.

II. Circuit Varieties and Characteristics

The circuits were divided into 10 categories: single gates, dual gates, voltage pulse gates, quad gates, power gates, receiver gates, double D flip-flops, 4-bit half adders, 8-bit shift registers, and reference sources. Two of these types (double gates and shift registers) are diagrammed below: the dual gates are shown in Figure 2 and the shift registers in Figure 3. The circuit characteristics are as follows:

- ① Cutting the emitter follower off from the emitter resistance can produce a "wired or" output, which expands the chip's logical capabilities and saves power, as well as allowing impedance matching with the system.

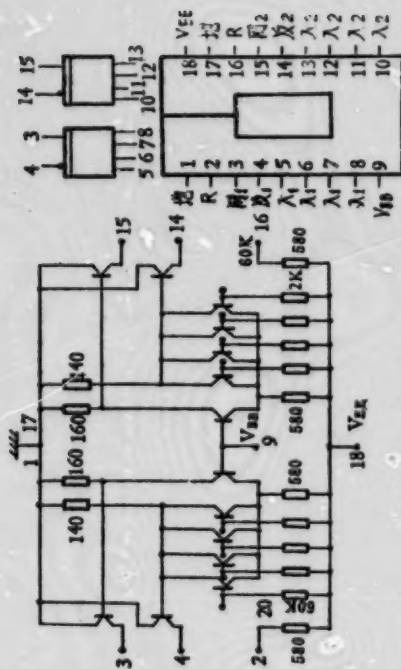
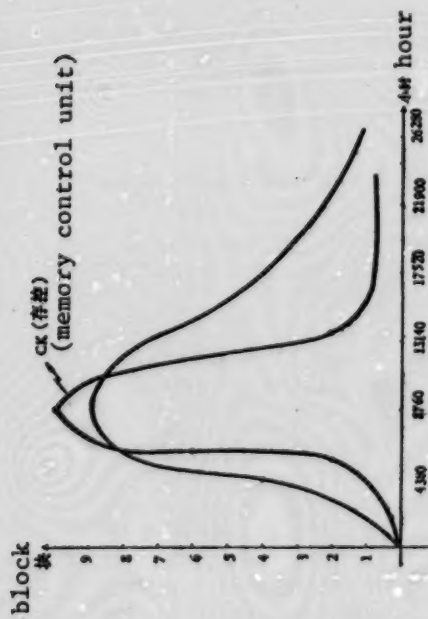


Figure 2. Dual Gate Circuitry

Note: Pins 1, 17 are ground; 3 and 15 are net 1 and 2; 4 and 14 are opposite 1 and 2; 5-8 are output 1; 10-13 are output 2

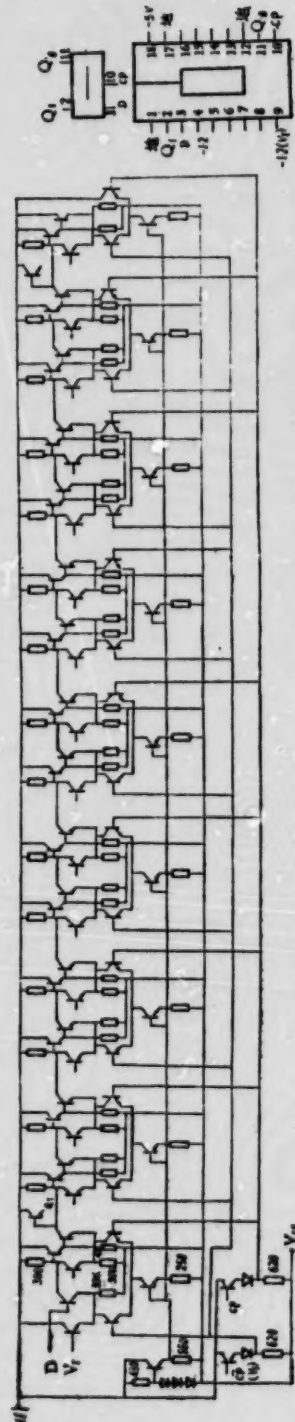


Figure 3. Circuitry of 8-Bit Shift Register

Pins 1, 12,
and 17 are
ground

- ② Each base input terminal has a base pull-down resistor, which avoids the low frequency effect resulting from input "float." This also decreases input capacitance and makes the changes on the output side in response to the load small.
- ③ Connection to an external reference source. Under current domestic production conditions, this helps to increase the chip acceptance rate and provides more possibility for flexible adjustment of the high- and low-voltage noise immunity. In addition it makes for convenience in measuring noise immunity, particularly for two-way inputs.
- ④ The three MSI circuits greatly increase the 757's gate-to-pin ratio and are key components in the 757.
- ⑤ Decreased power consumption, increased number of microscopic inspections, addition of a silicon nitride protective layer, rigorous screening, and testing.

III. Technical Characteristics

- ① The gate circuits and three circuit varieties described below operate at a voltage of -5 V. The power consumption is 25 mW per gate. The voltage level is from -870 mV to -1,750 mV.
- ② The double-D flip-flop uses a two-layer current switch. It has 62 transistors and 32 resistors. In terms of capability this is equivalent to 12 gate circuits. The maximum operating frequency is 200 MHz, the average delay is less than 8 ns, and the power consumption is 100 mW.
- ③ The 4-bit half-adder is the key component in the 757 machine's addition tree and checking circuitry. It too uses a double-layer current switch, and each half-adder has 50 transistors and 18 resistors, with an average delay equal to or less than 5 ns.
- ④ The 8-bit shift register shown in Figure 3, can replace random-access memory. Each register consists of 87 transistors and 62 resistors and has an operating frequency of 100 MHz. It has a capability equivalent to 96 gate circuits, its power consumption is less than 200 mW, and the average delay is less than 8 ns.
- ⑤ Circuit noise immunity. As is generally known, ECL circuits can use low-resistance transmission and matching. In the transmission process we specified that the noise immunity at both high and low levels should be 150 mV. The results of more than 2 years of machine operation indicate that these requirements were essentially met.
- ⑥ The devices are categorized according to voltage levels and are selected for use strictly in accordance with this classification. The changeover region of the gates is generally 250-300 mV, and the reference voltage tolerance is ± 25 mV. The central value of the reference voltage is specified as -1,200 mV and there is normal switching guaranteed to be between

-1,050 and -1,350 mV. Power supplies of -5 V and -2 V opposing voltage [?] [duila] [1417 2139]] by 10 percent of the measurements. In actual use, the packages are classified and used with reference to load conditions.

(7) Transmission. Transmission matters are a very important topic in high-speed digital systems. When a signal is transmitted along a line, it does not merely consume energy (because transmission lines have interface losses) and increase delays; in addition, in an incompletely matched system it also encounters multiple reflection and crosstalk, which affect the system's stability and reliability. The transmission paths in the 757's circuits run from the card interconnections and connectors to the printed circuit boards; those more than 10 cm long generally use 95-ohm twisted pair lines before being connected to the racks via connections and long lines. In order to minimize reflect and crosstalk, 95-ohm impedance matching is used throughout the system. The actual measured resistances of the printed circuit boards are 80-90 ohms, and the high temperature resistance of the paired wires is 95 ohms, while the chip pulldown resistances are 95 ohms. Thus the entire system other than the connectors has an essentially continuous, matched impedance, so that the reflection coefficient is very small. The measured waveform in the machine (Figure 4) shows that the system basically has complete matching, and wave distortion is very small.

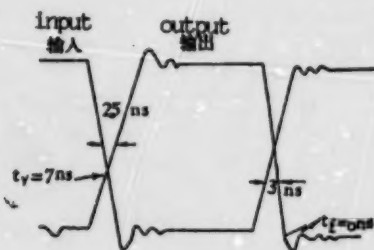


Figure 4. Actual Waveform for Machine With Seven Loads

IV. Printed Circuit Cards and Boards

In order to contain more information lines, to increase layout density, to decrease the length of interconnections and to make transmission easier and help assure uniform system impedance, we used printed circuit cards and boards.

1. Requirements for Printed Circuit Cards

(1) The electrical characteristics of printed circuit cards must meet signal continuity requirements, have uniform, consistent impedance, be matched to the system impedance, and must have good grounding and power supply systems in order to suppress noise and to keep all card noise within the permitted range.

(2) The layout density and gate-to-pin ratio must be maximized and card metallization requirements must be minimized.

(3) Account must be taken of overall machine layout and its requirements.

(4) Design should be based on card fabrication technology and every effort made to increase product acceptance rates and assure quality and reliability.

(5) Provision should be made for automating logic partitioning and the production process, and suitable provisions should be made for debugging.

2. Characteristics of the 757's Printed Circuit Cards

(1) Dimensions and Structure:

Measurements are 175 x 278 mm². A card has two 72-line printed connectors (a total of 144 lines), of which 36 are grounded and 108 are used for signal input and output. There are 50 inspection holes in the upper left corner, and the card has 5 rows of 18-pin DIP packages, each row divided into 10 or 16 chip areas, including 2 voltage reference chips. Below each chip is an 0.01 μ F high-frequency filter capacitor to filter the reference voltage, and a matching resistor network is mounted between each two lines of chips and outside the rightmost and leftmost chips; these are six-line single in-line [SIP] packages. Below the resistor network is installed an 0.01 μ F high-frequency filter capacitor. The -5 V and -2 V power supplies have 20 to 65 high-frequency filter capacitors, respectively, and a low-frequency high-capacitance 30 μ F clamping capacitor is installed at the -5 V and the -2 V input; thus every board can have a maximum of 80 18-pin DIP chips and 85 6-pin SIP resistor networks, 165 0.01 μ F high-frequency filter capacitors and 2 low-frequency capacitors. The card layout is shown in Figure 7.

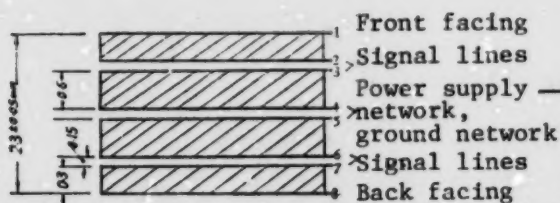


Figure 5. Layered Printed Circuit Board Structure

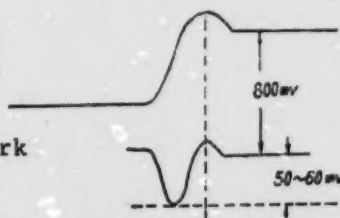


Figure 6. Noise Waveform

Note: The lower voltage level in the 800-mV interval is the lower limit of the waveform shown

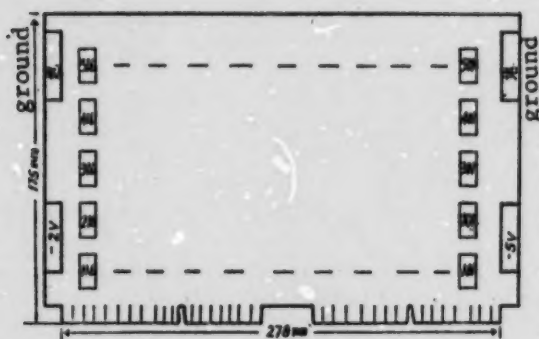


Figure 7. Card Layout

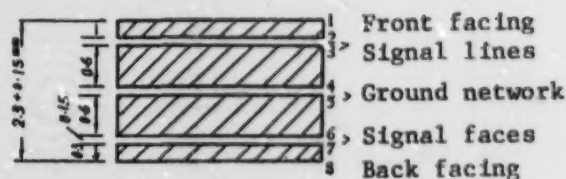


Figure 8. Layered Structure

(2) Layered Structure

If the printed circuit resistances are uniform and if the ground and power supply networks have sufficient capacity, a rather large number of working paths and a rather high layout density can be achieved. The 757 machine's printed circuit boards have eight layers, with the top-most and bottom-most layers as panels. On one side of the components is a -2 V power supply network, while only solder pads are on the other side; signal connections are run on layers 2, 3, 6, and 7, while the ground and power supply networks are on layers 4 and 5, with the -2 V and -5 V power supplies on the same layer. The boards are 2.3 ± 0.15 mm thick and the metallized holes have a diameter of 0.9 mm. The overlap structure is shown in Figure 5.

(3) Hole Layout and Interconnection Method:

The chips used in engineering the 757 were 18-pin DIP components with a pin spacing of two lines of pins 7.5 mm apart and a pin spacing of 2.5 mm. The hole spacing used on the cards is 2.5 mm x 3.75 mm, with the 72 connectors spaced 3 mm apart. Problems involving conversion to the internal network are solved by card layout. The internal vertical and horizontal lines are 1.25 mm from the holes. The holes with a spacing of 2.5 mm each have one cross line, and those with a 3.75 mm spacing each have two lines. The lines are 0.2 mm wide.

(4) Electrical Parameters:

Experimentally determined parameters: $C = 80\text{--}90$ pF/m (capacitance per unit length). $L = 0.6 - 0.8$ $\mu\text{H/m}$ (inductance per unit length). $Z_0 = 80\text{--}90$ ohms (impedance of printed interconnections; $T_d = 0.075 - 0.8$ ns/cm (no-load delay); $R_d = 0.02$ ohms/cm (DC resistance of signal lines).

The interconnections' characteristic impedance of 80-90 ohms is in relatively good agreement with the system impedance, but in the presence of capacitance it is somewhat decreased. The equation is $Z_0^1 = Z_0 \frac{C_0}{C_0 + C_s}$ (empirical formula),

where C_0 is the intrinsic capacitance, C_d is the capacitance under load, and Z_0' is the impedance in the presence of capacitance. The no-load delay T_d is 0.075 - 0.08 ns/cm; the delay is higher when a load is present:

$$T_d' = T_d \cdot \sqrt{1 + \frac{C_d}{C_0}}. \text{ Currently, the load value is } T_d' \leq 0.1 \text{ ns/cm.}$$

(5) Noise Problems of Printed Cards

- ① Ground Connection Noise: If there are 60 simultaneous transitions on the card, the maximum noise on the ground connections is 50-60 mV. The noise waveform is shown in Figure 6.
- ② Contact Pin Noise: In order to combat contact pin noise, it was decided to ground one-fourth of the contact pins in the 757 mainframe, so that the ratio of ground pins to signal pins is 1 to 4. When a certain signal pin is in a static state and the six signal pins around it transmit signals of the same change simultaneously, the noise induced in the static signal pin does not exceed 90 mV. The actual circumstances are better than the experimental circumstances (see Figure 12).
- ③ Crosstalk Between Parallel Wires: When two parallel transmission lines are close together, the capacitance between them and their mutual inductance may produce crosstalk. The measured interference between overlapping parallel lines in adjoining layers is the most severe type of interference between lines, and the maximum crosstalk figures are as follows:

<u>Length of overlap and parallelism</u>	<u>Maximum crosstalk voltage</u>
10.75 cm	270 mV
12.75 cm	290 mV

On average, for each centimeter of parallel overlap, the crosstalk can be as great as 25 mV. Accordingly, overlap must be minimized.

3. Printed Backboards

- (1) Dimensions: 234 x 300 mm², contain 24 72-line spring-loaded receptacles and can hold 12 cards. There are 91 connector holes on the right and left.
- (2) Layered structure: Same as for cards, except power supply network is replaced by ground network (see Figure 8).
- (3) Wiring paths:
 - a. with a hole spacing of 3 mm, one line can pass between them;
 - b. with a hole spacing of 4.5 mm, two lines can pass between them;
 - c. with a hole spacing of 3.75 mm, two lines can pass between them. Other electrical characteristics are the same as for the cards.

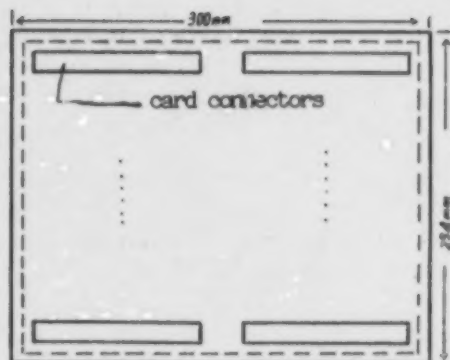


Figure 9. Printed Backboard Layout

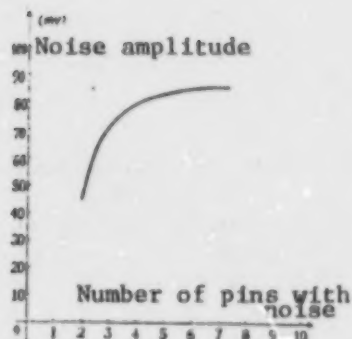


Figure 10. Card Noise

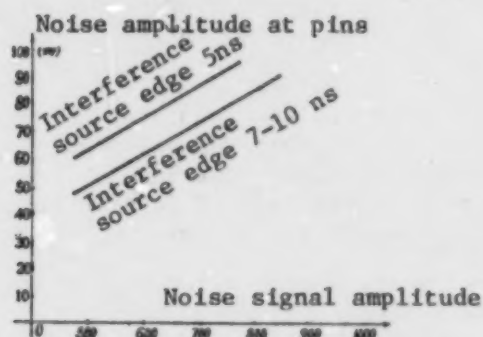


Figure 11. Amplitude Change of Noise Signal for Different Noise Source Amplitudes and Edge Changes

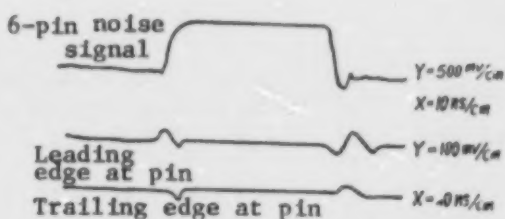


Figure 12. Noise Signal at Pins

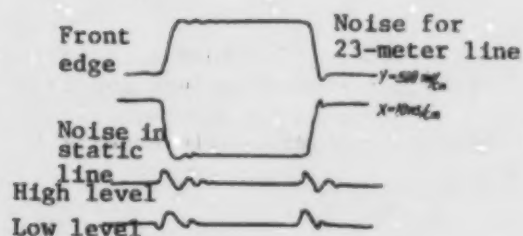


Figure 13. Noise Waveform for Long Line

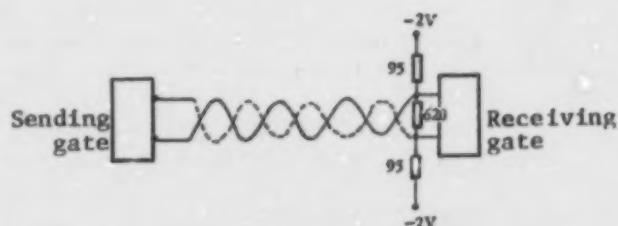


Figure 14. Use of Three Resistors To Replace Two-Resistor Matching

Each layer has 90 paths for transverse lines and 96 paths for vertical lines, and each card can hold a maximum of 1,000-plus lines (actual statistics). The surface layout of the card is shown in Figure 9.

4. Tests of Card Contact Pin Noise

Tests of card noise indicate that for six connectors or more the amplitude of the noise signal is constant (see Figure 10).

The relationship between the interference edge and the amplitude of the interference signal received at the pins can also be seen. As Figure 11 shows, the quicker the edge, the greater the interference signal.

V. Tests With Long Lines

In computers and control systems using large numbers of digital circuits, the connections within an individual circuit must follow certain logical requirements. Some of the interconnections are rather short, such as those between neighboring chips on a card, but some are rather long, such as connections between frames. Tests show that the transmission speed in some electric circuits is very high, close to the speed of light. The shortness of this transmission time clearly is not critical for low- and medium-speed digital devices, but as highly integrated circuits have been developed and put into use, the situation has changed. For example, the gate delay of high-speed ECL circuits is 2-4 ns, or even as little as 1 ns. In this case the transmission delay is much greater than the gate delay. But the problem is not simply the transmission delay: a more important factor is that when a rapidly changing signal is transmitted along a long line, reflection may occur, seriously distorting the signal waveform and producing various harmful interference pulses which hinder the normal operation of the entire system. Therefore, in high-speed digital computers, signal transmission has become an important problem that must be solved during design. We call the interconnections in which transmission delay must be taken into account "transmission lines" or "long lines." In engineering the 757, transmission lines 2 meters long or more were regarded as long lines. The wave resistance in the 757's long lines has been found to be 150 ohms, and the transmission delay is 5-6 ns per meter. Here we focus on solving the following problems: 1) loss problems: if we use a 5-meter line with load, the waveform obtained when a signal with an edge of less than 8 ns is used to drive it, the measured waveform agrees with that derived from the Bessel function, and accordingly in analyzing long lines this can be regarded as a lossless line. 2) Basic

$$L_0 = \frac{L}{M} = (7.3-7.5) \times 10^{-4} (\text{MH}); C_0 = \frac{C}{M} = (45-49) \text{pf}; Z = 130 \Omega \sim 140 \Omega$$

parameters: inductance and capacitance per meter. 3) Signal transfer method: bidirectional transfer, i.e., conjugate form. 4) Matching method: here we discuss matching in which three resistors replace two, as shown in Figure 14. We calculate $R_1 = 95$ ohms, $R_2 = 620$ ohms. In order to save space, we construct a matching network. This type of matching produces good results with little waveform distortion and little loss of level. The reflection coefficient is extremely small.

We also made crosstalk tests which demonstrated that with a group of 10 lines, the noise waveform on one of them which is quiet while the other 9 are carrying signals is very small, no greater than 50 mV (see Figure 13).

Twisted pair lines with biphase transfer were designed for an impedance of 150 ohms. The bandwidth of the lines is 80 MHz, and there is essentially no amplitude loss in them because the resistance of multi-leg lines is small.

VI. Design of Twisted Pair Lines

Twisted pair lines are one type of transmission line used in recent high-speed computers and communications networks. Although they are inferior to coaxial cables in frequency terms, their wave resistance is high, they are of small size and flexible. In addition, twisted pair lines are particularly suited to complementary signal transmission, and the crosstalk between them is extremely small. But the problem of how to design such lines to give the impedance requested by the user, i.e., how to choose their external and internal diameters, is still a difficult one. However, we finally achieved a solution through analysis and computation.

VII. Transmission Requirements

In order to make the most rational use of chips, the line noise is kept within the permissible range; the noise immunity is considerable. We analyzed the multiple reflection of ECL signals in transmission lines and derived the formula relating the voltage at the terminals and the load to time and various parameters when the lines are driven by ECL circuits and they are affected by both concentrated and distributed loads; we used a computer to predict the waveform, achieving excellent results.

Some of our results were as follows: Because current switches can provide "wired OR's," we specify that all output terminals forming part of wired OR's and their loads must be distributed on a transmission line in order to prevent reflection, and cannot branch. In general, the maximum permissible distance between "dotted OR's" is 80 mm. In all circuits we specify that the load factor must not exceed eight. Matching resistors must be provided at terminals. In general, only one driver card is allowed; the maximum is two. The total number of loads also must not exceed eight, and so on. We will not list more detailed prescriptions here. Because a determined effort was made in this area during implementation of the machine, the overall operation of the machine is excellent.

VIII. Operating Principles of ECL Circuits

The ECL gate circuit is a differential amplifier type and its current is essentially constant. If one terminal is connected to a reference source and the other terminal to a dynamic signal, the signal will fluctuate by 400 mV above and below the reference voltage. In high-level output, the input channel is closed. When the input is low, the reference channel is closed. The output is driven by a follower, and it can supply a low internal resistance, high drive capability load. Measurements on such gate circuits under dynamic conditions indicate that the gate delay at each level is 2 ns and the power consumption 25 mW, and with a power supply of -5 V. The follower resistance is connected externally. The 757 used a 95-ohm matching network. The forward edge and rear edge are both 6-8 ns (with

eight loads). The Boolean expression is: $\bar{3} = \bar{5} \cdot \bar{6} \cdot \bar{7} \cdot \bar{8}$ (for the case of a double gate); see Figure 2.

The ECL flip-flop is a double D flip-flop; two flip-flops are included in each package and there is a pulse input terminal, a reset "0" terminal and two set "1" terminals. Every flip-flop has two data input terminals. The usual Boolean expression is $Q^{n+1} = C_p(D_1 + D_2 + \bar{R}S) + \bar{C}_p Q^n$, where C_p is the pulse input, R is the reset terminal, and S is the set terminal. D_1 and D_2 are the two data input terminals. Q^n is the device state set by the previous pulse, and Q^{n+1} is the device state during the present pulse.

A half-adder is a device which is capable of summing and carrying. Like the flip-flop, it is also a tower [?] [baota [1405 1044]] current switch, whose lowest level is DC, and the logical operation which it carries out is $AB + \bar{A}\bar{B}$, where S is the half-sum, A and B are the input signals, and C = AB, where C is the carry bit. In the present case, because of a limited number of connections, C did not output. Every package in it has four half-adders. The delay is 4-5 ns at each level.

A shift register contains 8 bits, all of which are in a single package, and only the first and eighth bits (called Q_1 and Q_8) are output. Each bit has an input voltage, but there is no set or reset signal, and it is only possible to enter a 0 or 1. Clearing an 8-bit shift register requires nine counts. To change all 8 bits from 0 to 1 requires a 1 input for 9 counts. There is an 8-ns delay for each bit in the shift register; the Boolean expression for Q_1 is $Q_1^{n+1} = C_p D_1 + \bar{C}_p Q^n$ (see Figure 3).

IX. Conclusions

To summarize our experience, the 757 machine provides a 17.5 level logic chain and 2 meters of lines with a 100-ns cycle, and there is only a 10-ns margin after computation, which is somewhat too small. In addition, the 2 meters of line is hard to achieve at current domestic levels of integration.

The foreign MU-5 is also an ECL circuit, with a cycle of 50 ns, whose logic chain only permits 8 levels, each with a delay not exceeding 4 ns, with the lines included within the eight levels. The ILLIAC-IV has a cycle of 67 ns and the lines and delay are specified as 5-15 levels, with 20 levels permitted under extraordinary conditions. The margin after computation is 30 percent in the MU-5; that in the ILLIAC-IV is 25 percent.

The 757 machine has a margin of only 10 percent, so that currently it is operated normally at 110 ns. In order for machine operation to be reliable, 8.5 MHz is specified. It should be pointed out that most of the gate delays in chips involved in transmission are 2.5-3.5 ns, and the delay per meter of printed circuit connection is 8 ns, while that per meter of twisted pair line is 6 ns. These values are all smaller than the figures given in the engineering standards. If the total delay of a chain measured in the ALU is 110 ns and the circuit delay is only 49 ns, the line length exceeds 5 m. This

indicates how harmful the delay in the wiring is, since it is hard to keep it within 2 m.

Furthermore, the project specifications state that in order to make the boards capable of accommodating more wiring, it is desirable that their size be further increased, (some difficulties are currently being encountered in the process). In the case of cards, we distinguish type A boards (no double rows of holes for device pins) and D type (double rows of holes for device pins): in changing the wiring, it is desirable to use more D-type cards, but this decreases packaging density. The problem of how to design future printed circuit board substrates and boards requires examinations.

Research and development on the 757 machine promoted the development of semiconductor and electronic component manufacturing processes. Because the 757 machine largely makes use of automation techniques, CAD [computer-aided design] was developed.

Those involved in the 757 machine hardware engineering project also included Comrades Zhang Shuwen [1728 3219 2429], Wang Gonghao [3769 0361 8504], Liang Peiji [2733 1014 1015], Chen Hong'an [7115 7703 1344], Huang Zhenyun [7306 6297 5619], Xu Xingsheng [1776 5281 5116], Liu Pixuan [0491 0012 4821], Liao Qingyu [1675 3237 5940], Li Wenyin [2621 2429 6892], Sun Xiangjun [1327 4382 7486], Lu Pinghe [4151 1627 0735], and Jin Lianyi [7246 6647 5030].

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DESIGN, CHARACTERISTICS OF 757 VECTOR COMPUTER MEMORY CONTROL UNIT

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 2, 1984, pp 26-33, 16

[Article by Xia Shaoze [1115 4801 3844], Institute of Computing Technology, Chinese Academy of Sciences (CAS)]

[Text] The 757 machine system uses an architecture consisting of a mainframe and an auxiliary machine, between which information is exchanged by two methods. In the first, the communications channels are used to transmit control signals in the interrupt mode, while the other uses a fast batch transmission channel in which data is transmitted in batch form in the time-sharing mode. The 757 vector machine's memory control unit controls the communications channels between the mainframe and the auxiliary machine and exchange of signals on the fast batch transmission line. In addition, the memory control unit is connected by instruction or data channels to the instruction control unit and the operation control unit. In short, the 757 machine's memory control unit carries out information exchange between the vector processor, the peripheral processor, magnetic disk (or tape) and the vector processor's main storage. Seven channels can make simultaneous requests to the memory control unit, which performs time-share queuing, address processing, and address mapping in accordance with priority, processes instructions in accordance with functional requirements, and accesses the relevant memory until processing of the requests is completed.

The 757 vector machine uses a parallel interleaved single-pipeline architecture, and the memory control unit is geared to this type of operation. In order to further increase the machine's speed and efficiency, to make full use of the pipeline architecture, and to minimize speed degradation resulting from collision problems, the memory control unit has been provided with a collision processing capability, and the altered readout technique. In order to increase machine reliability, in addition to fault diagnosis of the memory control unit, instruction-level retry and memory-level double calculation are provided. In addition, the memory operates in modular fashion and performs such measures as switchovers, disconnection of units, address mapping, and the like. Because of the use of these technologies and features, the memory unit economizes on hardware, and has a rather high speed and relatively high efficiency.

Below we briefly describe some of the principal problems involved in memory control unit design and the unit's design characteristics. For convenience in dealing with the topic, we first outline the memory control unit's architecture and mode of operation.

I. Structure and Mode of Operation of the Memory Control Unit

1. Time-Sharing Queuing of Requests

The memory control unit operates in the pipeline mode with a seven-station pipeline. Time-sharing queuing of requests is done at stations 0 at the beginning of the pipeline. The memory access requests from different locations are queued according to priority and are handled in the time-sharing mode in accordance with the memory control unit's clock pulses. This time-sharing processing of requests by beat means that although requests from the various channels may appear randomly, only one request can be processed per beat; the top-priority request is forwarded to the following stations of the pipeline. In order to increase the rate of information exchange between the peripheral processor (the auxiliary machine) and the vector processor (the mainframe), direct fast batch data transmission channels are used. Channels P_0 and P_1 (disk 0 and disk 1) are connected to a 2 MHz magnetic disk unit, and because the exchange signal is timed, P_0 and P_1 are given the highest priority. In addition, there is an instruction fetch channel, a data send store channel, a fetch and send channel, and two peripheral processor channels, as shown in Figures 1 and 2.

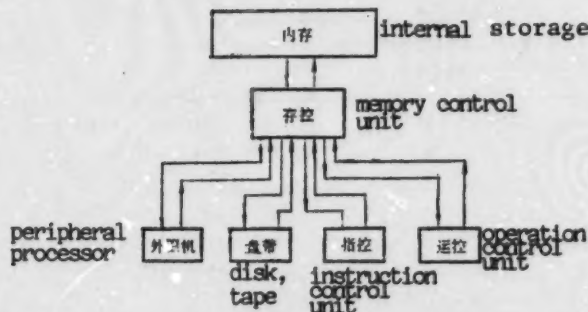


Figure 1. Memory Control Unit External Connections

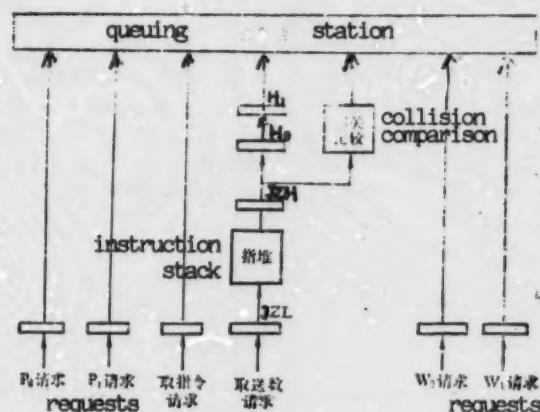


Figure 2. Request Queuing Station

To adapt the device to magnetic disks and increase the main frequency, the memory control unit has two disk buffer registers and read-write control circuitry.

2. Fetch-Send and Send Channels

These two channels include an instruction fetch and send stack station, two data send instruction holding registers (H_0 and H_1), and a collision comparator. The data send instruction read out from the instruction stack requires look-behind data which has not yet been processed and prepared in the ALU, the data send instruction is placed in H_0 and H_1 , and the next data instruction is compared with these two data-send instructions which are in the wait

condition; if there is no collision, it can be moved ahead in the queue for execution.

3. Pipeline Stations

Requests from all of the channels require exchange of an array. Generally, only the initial address forwarded after instruction processing, the address mapping method, the increment, and the number of exchanges are processed by the memory control unit. In accordance with the relevant address mapping method, the memory control unit finds the logical address of each component, then looks at the page table to find the real address; then, depending on whether the memory unit is in the switched-in or disconnected state, it converts it to the true internal storage access address.

In accordance with the capabilities of the 757 vector machine, in order to enrich the vector processing methods and expand the range of vector computations, the compression and restoration vector h and the indirect control vector Q have been provided, and there is a requirement for two different address-forming methods: ① scalar, $D' = D$ or $D' = D + (Q_1B)$; ② vector, $D' = D + 1'(BE)$ or $D' = D + (Q_1)$.

Thus the component increment (BZ) or the indirect control vector (Q) can be used to modify the address. In addition, it may be controlled by the compression and restoration vector (h). When the address modification makes use of the component increment (BZ), h serves to control compression and restoration; but if the instruction is controlled by both the direct address ($\bar{Q}$) and by h , then h determines whether or not the fetch or storage operation is carried out.

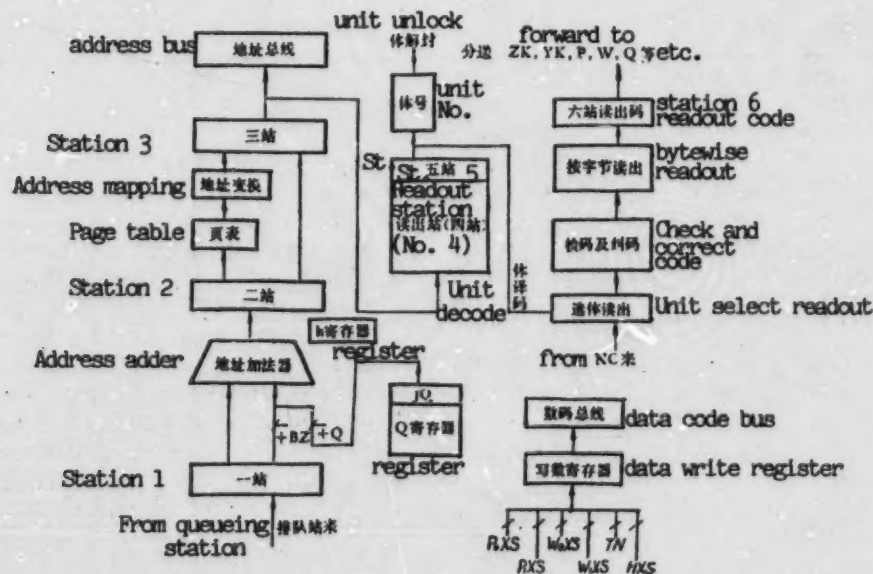


Figure 3. Rough Block Diagram of Memory Control Stations 1-6

An example:

	$\bar{h}$	$\bar{h}$ control $(\bar{L}) \xrightarrow{\quad} D + (BZ)$ compress	Result	$\bar{h}$	$\bar{h}$ control $(D + (BZ)) \xrightarrow{\quad} \bar{L}$ restore	Result ($\bar{L}$)
	$\bar{h}$	$\bar{h}$ control $(\bar{L}) \xrightarrow{\quad} D + (BZ)$ compress	Result	$\bar{h}$	$\bar{h}$ control $(D + (BZ)) \xrightarrow{\quad} \bar{L}$ restore	Result ($\bar{L}$)
$\bar{D} = D + (BZ)$	0	x_0		0		0
	0	x_1		0		0
	1	$x_1 \rightarrow D$	$(D) = x_1$	1	$(D) = x_1 \rightarrow L_1$	x_1
	0	x_2		0		0
	...	...		...		...
	1	$x_2 \rightarrow D + (BZ)$	$(D + (BZ)) = x_2$	1	$(D + (BZ)) = x_2 \rightarrow L_2$	x_2
	0	x_3		0		0
	...	...		...		...
	1	$x_{14} \rightarrow D + 2(BZ)$	$(D + 2(BZ)) = x_{14}$	1	$(D + 2(BZ)) = x_{14} \rightarrow L_{14}$	x_{14}
	0	x_{15}		0		0
$\bar{D} = D + (Q)$	$\bar{h}$	$\bar{h}$ control $(\bar{L}) \xrightarrow{\quad} D + (Q)$	Result	$\bar{h}$	$\bar{h}$ control $(D + (Q)) \xrightarrow{\quad} \bar{L}$	Result ($\bar{L}$)
	0			0		0
	0			0		0
	1	$x_1 \rightarrow D + (Q_1)$	$D + (Q_1) = x_1$	1	$(D + (Q_1)) = x_1 \rightarrow L_1$	x_1
	0	x_2		0		0
	...	...		...		...
	1	$x_2 \rightarrow D + (Q_2)$	$D + (Q_2) = x_2$	1	$(D + (Q_2)) = x_2 \rightarrow L_2$	x_2
	0	x_3		0		0
	...	...		...		...
	1	$x_{14} \rightarrow D + (Q_{14})$	$D + (Q_{14}) = x_{14}$	1	$(D + (Q_{14})) = x_{14} \rightarrow L_{14}$	x_{14}
	0	x_{15}		0		0

It can be seen from Figure 3 that stations 1 and 2 are provided to complete the above two types of address modification. From station 2 to station 3, the page table is consulted and the address mapping is made in accordance with the switched-in or disconnected state. To adapt to the machine's multi-programming operation and memory protection features, the memory control unit has a page table memory with a capacity of 128K: each page has 4,096 internal storage cells. The word length in the page table is 14 bits, of which 7 give the actual page number, 5 give the protection key, and each of these divisions has a parity bit. The machine has three modes of operation, i.e., kernel, supervisor, and computation, and there are three protection states: read enable, write enable, and execute enable. The page is provided with protection rules, and if these are violated a page fault interrupt is generated (YBBF).

From stations 3 to 4 in the pipeline, the internal storage unit number and true address resulting from address mapping are sent simultaneously via the address bus to the 18 units, while the access signal is sent to only one of the units, and that unit is locked. If it is decided to write into main memory, the data code is simultaneously sent to the 18 units by the data write buffer. This type of bus operation saves considerably on hardware. Station 4 is used to record instructions, byte characteristics, the number of the internal storage unit access, the characteristics of the read-write commands and the like. Eight shift registers provide a delay while waiting for the internal storage readout.

From station 5 to station 6, a number read out from memory is received, undergoes byte conversion and is sent to various channels. In addition, this datum read out of internal storage is diagnosed and the code corrected. A single bit error can be corrected, after which the correct code is sent out bitwise. In station 2, a check is made to see whether the addresses of the two immediately adjoining fetches are the same; if the data is fetched in bitwise fashion and the preceding and following component fetch cells have the same address, another read from memory is not required: the unlocking of the unit is simply delayed until the two addresses are different. This saves time and increases efficiency.

II. Collision Processing

The 757 mainframe is a single-instruction flow, single-data-flow lengthwise-crosswise vector processing machine. The control components all have pipelined architecture and all operate with parallelism and overlapping. The main obstacle affecting the smooth parallel overlapped operation of the three control units' pipelines is the various collision problems such as jump collisions, operation collisions, data fetch and send collisions, storage unit collisions and the like. Here we limit ourselves to describing a few of the collision problems encountered in the 757 vector machine's memory control unit and means of resolving them. Memory control unit collisions primarily entail collisions within the instruction flow or data flow and relations between the instruction flow and data flow. These factors affect normal use of program states, memory unit states, page contents, and the fetching and forwarding of internal storage addresses. Handling of collisions must above all be logically correct, and in addition must maximize the machine's speed and efficiency. Some problems which are difficult to handle in hardware can be handled by software.

1. Collisions Between Channels

The channels operate in the time-sharing mode, and the disk and tape channels exchange arrays with internal storage in batch form via the memory control unit, generally using true addresses (without protection); the peripheral processor has the right of initiation. The instruction fetch channel's execution program is edited and processed by the peripheral processor. Therefore, when internal storage addresses are used in distributed fashion, the user has to provide for this in advance, and the software processes the collisions.

2. Collision With Machine Status Word

When a transfer to supervisor instruction is encountered in the instruction flow (exchanged between internal storage and central numbering register), processing before and after this instruction is in accordance with different program status words and memory unit states. Before this transfer to supervisor instruction is executed, the machine stops dispatching the next instruction and executing the next program, and the instructions remaining in the instruction buffer are discarded. After this transfer to supervisor instruction is executed, a new instruction is fetched in accordance with the new machine status word and executed.

When a page table send instruction is encountered in the program, following this instruction, internal storage is addressed in accordance with the new page table. In general, changing of the page table state is controlled by the operating system, operating in the kernel state, and after the page table has been sent, a change of state instruction must follow; operation then continues in accordance with the new page table state.

3. Data Fetch and Send Collisions

The 757 machine is a crossbar vector machine, and a vector instruction may have from 1 to 16 components. The maximum number is 16, and the data fetch and send address is obtained by first having the instruction controller determine the real address by the operation $d + (b)$, after which it sends this starting address to the memory control unit, which then must use various modification methods, i.e., use of the component displacement (BZ) or indirect control vector (Q) to process this address. In order to assure correctness and increase efficiency, collision processing is peripheral after the instruction reaches the memory control unit and before request queuing. But at this time there is no way of knowing the specific address of the 16 components following modification, and the specific content of the indirect control vector cannot be read out, so that decisions on address collisions are rather difficult and complex. Because the operand read out of internal storage is sent to the ALU via the memory control unit and the result obtained by the ALU is sent to the instruction control unit's look-behind data send station, then returned to main storage via the memory control unit, the entire flow path is long, and the data send results are not obtained very rapidly. Thus, if the data fetch and send is carried out in sequence, this seriously degrades the speed of the mainframe. Therefore, collision processing must be done for data fetch and send, so that fetches and send operations which involve no memory space collision can be carried out first; although this method requires a slight increase in hardware, machine simulations indicate that collision processing on data fetch and send by the memory control unit can increase machine efficiency by 30 percent or more. Moreover, measurements on the seven different problem types indicate that collision processing decreases computation time and yields a relative increase of 65 percent in speed.

Instructions are generally executed in sequence, but if a look-behind data send instruction is encountered, and the datum is not yet ready at the look-

behind station, the data send instruction is placed in data send wait stations H_0 and H_1 . If the subsequently arriving data fetch and send instruction has no collision with the previous data fetch and send instruction, it can be moved up in the queue and executed. Instructions in which there is a collision should be placed in the instruction stack; and the later instruction in which there is a collision are executed after the earlier data send instructions are completed. The following four situations can arise with data fetch and send instructions:

	<u>Earlier instruction</u>	<u>Later instruction</u>
①	send	send
②	send	fetch
③	fetch	send
④	fetch	fetch

In situation ①, the look-behind instruction fetch obtained from the computation result is processed in strict sequence. If a data send instruction which does not use the look-behind buffer appears, the collision comparison is made in terms of the internal storage addresses used, and if there is no collision, it may be moved up and executed. In situation ②, if the following fetch instruction involves no collision with the internal storage address of the preceding data send instruction and the Q (indirect control vector) or h (compression and restoration vector) is used, it can be executed ahead of sequence. In situations ③ and ④, the earlier instruction is sent through first, followed by the later instruction. The address that is entered in the memory control unit has an initial address, an address modification method, and an increment. Thus, it is necessary to compare not only the initial address, but the modification range as well. This can be done with two address subtractors. The first compares the starting addresses and the second compares the starting address plus the modification range ($DE + 16 \Delta Z$ compared with $DH + 16 \Delta H$).

In internal storage address collision comparison, the initial internal storage address DZ in the transfer to stack buffer ($JZDH$) instruction read out of the instruction stack is compared with the initial internal storage address DH of the data send instruction in stations H_0 and H_1 . The comparison is carried out by using the first adder in pipeline station 0 as $DZ(0-18) - DH(0-18)$; when $DZ(0-18) = DH(0-18)$ a collision is recognized. If $DE(0-18) \neq DH(0-18)$, to simplify processing we distinguish two more situations:

* *

(1) Within the same vector loop [] or the program segment $T_{non} = 1$ or the instruction to be compared is a scalar and the corresponding stations H_0 and H_1 also contain scalar instructions. When $DZ(0-18) = DH(0-18)$ this is regarded as a collision, and if they are not completely equal the programmer must assure that there is no collision.

* *

(2) Collision processing of instructions not in the same []. When $DZ(0-18) \neq DH(0-18)$, a check is made to see whether the modified address

has a collision. It must also be borne in mind that the vector displacement (ΔZ , ΔH) or indirect control vector (QZ, QH) method can be used to modify the address, and the displacement may be positive or negative. In this way there can be eight possible combinations. The second-level adder in pipeline station 0 carries out comparison of the range, and identification of the result yields the condition for no collision. In addition, the internal storage space (520,000 words) is divided into 8 blocks, each containing 64,000 words. A simplified condition for no collision which assures correctness is the prescription that the address space displacement for 16 ΔZ , 16 ΔH , (QZ) and (QH) must not exceed 64,000. Collision comparisons may be made within the 64,000-word range, and cases in excess of 64,000 are treated as collisions.

When a new data fetch instruction and the data send instruction in stations H_0 and H_1 are not in collision, the instructions not in collision can be moved up in the queue and executed. These operations require a collision comparison time of one to two beats, and comparison with either H_0 or H_1 requires that the comparison be carried out by the second-level adder within one beat. Therefore the adder structure and the condition formulation must be meticulously designed in order to assure correct, rapid completion of collision comparison.

Figure 4 presents a block diagram of the collision comparison station for data fetch and send described above.

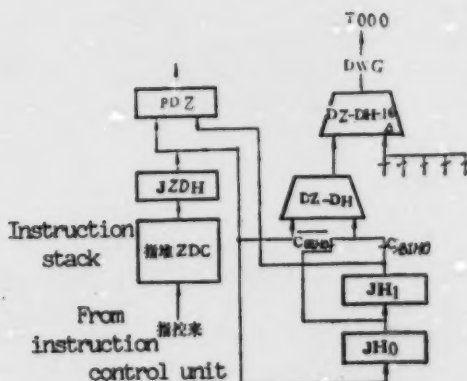


Figure 4. Collision Comparison Station for Data Fetch and Store Address

In addition to collision comparison for internal storage addresses, there are also problems involving comparison of Q and h. The 757 has send Q and use Q instructions and send h and use h instructions. If the Q to be used is in collision with the previous instruction requiring sending of Q which is present in station H, then the later instruction must wait; otherwise it can be moved up and executed ahead of sequence. The same applies to h.

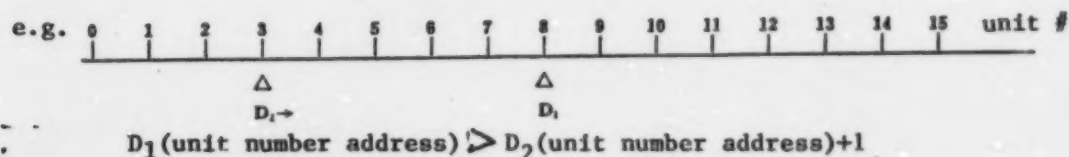
III. Altered Readout

The 757 vector machine uses 16 storage units, each with a capacity of 32,000 16-bit words, in modulo-16 operation. If the address modification increment for the 16 components of an instruction is odd, then in modulo-16 operation it is possible that none of the units will be in collision. But two vectors will not necessarily be continuous. If the former instruction fetches A (vector A) and the later instruction fetches B, the relationship between these two vectors may be of several types.

If vector A is fetched from units 0, 1, 2, ..., 15, and the fetching of B can begin from unit 1 or from unit 8 or 15, the memory cycle is 15 beats (1.5 μ sec), so that in terms of the overall probability of numbers of memory accesses, waits of 0, 1, 2, ..., 8, ..., 14 beats resulting from collisions may arise. If the probabilities are equal, then the number of waiting beats on the average will be

$$\frac{0 + 0 + 1 + 2 + \dots + 8 \dots + 14}{16} = 6.56 \text{ beats.}$$

The average waiting time of 6.56 beats resulting from memory unit collisions in fetch operations is quite considerable. Therefore, the altered readout approach was designed for the memory control unit. If the vector numbers of the preceding and following instruction are 16 and the increment is always (BZ) = 1, fetching of the following instruction begins at the unit next after the one in which the fetch of the previous instruction ends, and after 16 components have been fetched the vector is shifted to restore the correct form. In this way no waiting is required.



where D_1 indicates the number of the unit in which the second of the instructions begins; and D_2 is the number of the unit in which fetching of the first of the instructions ends.

Reading out of this instruction should actually begin from unit 8, but with altered readout it begins with the unit immediately after the one at which

readout of the preceding vector concludes. In the example above it begins with unit 4, and it can be seen from the table that starting at unit 4, 1 should be added to the unit address, while from unit 8 on, 1 should be subtracted from the address. Finally, because the vector position is not correct, it must be shifted to return the sequence to normal. The method is to use the condition that the unit numbers of D_2 and D_1 are equal to make the operation control unit start adding 1 to the cyclic 4-bit counter until the vector is completed. The final number of shifts should be equal to the complement of the 4-bit counter in question: in the example above, the shift is $(1100)_{\text{comp}} = 0100$, i.e. 4, so that unit 8 is shifted to the beginning of the vector.

Normal readout		Altered readout		Cyclic counter	
Cell address	Unit number address		Cell address	Unit number address	
100.....0	1000	+1	100.....01	0100	0000
100.....0	1001		100.....01	0101	0000
100.....0	1010		100.....01	0110	0000
100.....0	1011		100.....01	0111	0000
100.....0	1100	-1	100.....0	1000	0001
100.....0	1101		100.....0	1001	0010
100.....0	1110		100.....0	1010	0011
100.....0	1111		100.....0	1011	0100
100.....01	0000		100.....0	1100	0101
100.....01	0001		100.....0	1101	0110
100.....01	0010		100.....0	1110	0111
100.....01	0011		100.....0	1111	1000
100.....01	0100		100.....01	0000	1001
100.....01	0101		100.....01	0001	1010
100.....01	0110		100.....01	0010	1011
100.....01	0111		100.....01	0011	1100

It is evident from the foregoing that while altered readout adds a certain amount of hardware and complexity from the control standpoint, it has many advantages and it decreases the waiting time resulting from collision between units, thus increasing machine efficiency.

IV. Fault Diagnosis, Storage Odd-Weight-Code Checks, Instruction-Level Retry and Station-Level Double-Calculation

The 757 vector machine memory control unit has 31 error diagnosis points; at 25 of them, the machine is immediately stopped if an error occurs. The fault locations are kept within a small range in order to help with rapid discovery and elimination. The memory uses odd-weight code detection: it can correct single-bit errors and detect multibit errors. Because the memory has a relatively large number of units, the memory controller provides a common odd-weight code formation process and detection and correction circuits, which greatly decreases the amount of hardware needed.

When a datum read out of internal storage and received by the instruction controller contains a single-bit error, the error correction circuit corrects the error, records the number of the unit in which the fault occurred, and sends an access internal 2 (FNC II) code to rewrite the erroneous code within that unit. An extended read-write cycle is used to carry out the rewrite in the unit where the error occurred. New access can be made to that unit only after the rewrite is carried out and the memory control unit unlocks it. The objective of rewriting an erroneous entry in internal storage is to decrease the probability of 2-bit errors and to increase machine reliability.

Internal storage addresses, numbers read out of internal storage and numbers to be read into it are subjected to parity checks in the individual units, and if an error is discovered then the unit in question reports it to the memory control unit.

Addresses and data sent by disk or peripheral processor to the memory control unit use a common channel and are subjected to parity checks. If the memory controller finds an error in one of these data or addresses, it sends an error signal to the peripheral processor or disk. The peripheral processor or disk determines whether the error occurred in the sending of a datum or an address. In addition, after the memory control unit corrects single-bit errors read out from internal storage it sends them to a disk or peripheral processor. The memory control unit is also capable of timely detection of double errors in readouts; it then sends a double error marker to the disk or peripheral processor.

If a fault or error occurs in stations 1, 2, or 3 of the memory control unit pipeline, the memory control unit can carry out instruction-level retry, because the instruction in question has not yet been discarded from the memory control unit's instruction stack. If the detection point in station 1, 2, or 3 detects an error, it immediately stops the machine, and instruction control unit T_1 (unified numbering register 1) indicates a fault at the third bit in the memory control unit and turns control over to the general interrupt controller, then moves to the start of the diagnostic program. The memory controller's current state is recovered under the control of the diagnosis and recompute problem and analysis and processing are carried out. Because the lengths of time for which the various control units stop the machine are different, in order to assure that the on-the-spot memory control unit stops the machine in the same beat as the fault appears, while the instruction control unit and the operation control unit need only stop the machine in the next beat, start-stop processing is also necessary. Thus the instructions must be cleared from stations 4, 5, and 6 of the memory control unit pipeline and some registers such as the look-ahead and look-behind registers must be set in the state before the instruction in question was executed, after which the diagnosis program initiates retry by the memory control unit, and the subsequent retry process is performed by hardware. The retry process depends on the nature of the instructions at stations 1, 2, and 3; starting with station 3, every serial instruction fetched from the instruction stacks for stations 1, 2, and 3 is retried.

If there is an external disk channel instruction in station 1, 2 or 3, since such instructions cannot be retried, the only course is to regard this external channel exchange with the disk unit as failed. When the retrievable instructions for stations 1, 2, and 3 are retried, if an error does not arise, the "retry successful" signal is sent; this signal also requires that the memory control unit be stopped. After the diagnosis and recompute program detects the "retry successful" signal it makes a record and again starts the mainframe, and processing of the original program resumes. In the case of some jitter-type faults, retry can avoid change of path and stoppage of the machine, thus increasing machine availability and efficiency.

The 757's memory control unit also has station-level double-calculation. There are two types of station-level double-calculations. One is when a random jitter fault occurs in the station 0 collision comparator. This is reported to the general control and diagnosis program; after a program control delay of 200 msec the mainframe is restarted for reexecution, and if the fault is removed, operation may continue from the restart. In the other station-level double-calculation, a single error stops the station double-calculation. The memory control unit is provided with the C_{DCT} (single-error stop) flip-flop: when C_{DCT} is in the zero state the memory control unit can automatically correct a single-bit error in a datum read out of internal storage. When C_{DCT} is in the 1 state, if a 1-bit error occurs in the internal storage readout, the memory control unit must stop the machine (SMDCO). Similarly, bit 3 of T_1 reports to the general diagnosis controller, which switches to the diagnosis and double-calculation program. This program recovers and preserves certain error locations, finds the instruction that led to the error, and the number of the internal storage unit, after which the diagnostic program fans in the instruction to stations 3 and 5 and reads out an all-ones code and an all-zeroes code seven times from the unit which made the error. If an additional error does not occur during these seven readouts, then the memory control unit condition is restored, the program is used to correct the contents of the erroneous memory, and execution of the program is resumed. But if an error is still found during the seven readouts, this indicates a hard fault and the diagnostic program changes the memory unit status word and cuts out the malfunctioning unit, moves all of its contents to a backup unit, then restarts the mainframe and resumes execution of the program.

V. Memory Unit Switchover, Disconnection, and Address Mapping

The 757 vector machine's memory consists of 16 units and 2 backup units, each with a capacity of 32,000 words, or a total of $16 \times 32,768 = 524,288$ words. In general, at full capacity the machine operates modulo 16, and when one or two units are malfunctioning they are disconnected and replaced by backup units. Thus the unit can continue to operate modulo 16 with no loss of capacity. If a memory unit malfunctions while the program is being run, read and write are performed with a backup unit designated by the unit status word.

The internal storage into four major quadrants in terms of the highest address 01 bit, and the unit number is expressed horizontally from left to right. Accordingly, different lines express different unit addresses.

When there are more than two malfunctioning units, there are not enough backup units to serve as replacements, and it is necessary to disconnect some of the units. To assure continuity of addresses, at least four units are disconnected each time. If the number of malfunctioning units increases further, a maximum of eight can be disconnected, but they can only be within the same M8.

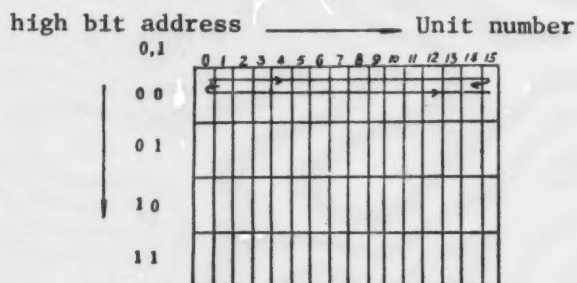


Figure 5. Modulo-16 True Address and Logical Address Operation

The machine can operate modulo 16 (M16), modulo 4 + modulo 8 (M4 + M8), or modulo 8 (M8).

In Modulo 4 + modulo 8,

<u>Amputated units</u>	<u>Unit numbers in M4</u>	<u>Unit numbers in M8</u>
QT ₀₋₃ (0-3)	4-7	8-15
QT ₄₋₇ (4-7)	0-3	8-15
QT ₈₋₁₁ (8-11)	12-15	0-7
QT ₁₂₋₁₅ (12-15)	8-11	0-7

In modulo 8 operation (number of malfunctioning units greater than 4),

<u>Amputated units</u>	<u>Unit numbers in M8</u>
QT ₀₋₃ , QT ₄₋₇	8-15
QT ₈₋₁₁ , QT ₁₂₋₁₅	0-7

When 4 units are disconnected, the internal storage capacity is decreased by 4 x 32,768 words. Because the operating system is stored in the last memory area, we regard the decrease as being the first one-fourth of the area. Only half of the first 260,000 units can be used, i.e., only 130,000, while the last 260,000 is entirely available. For example, when units 0-3 are disconnected, the correct addresses used by the first 130,000 units' cells are in units 4-7 in modulo 4 operation, while the last 260,000 are in units 8-15 in modulo 8 operation, as shown in Figures 6 and 7 (in Figure 7 units 0-3 are disconnected, units 4-7 are operating modulo 4, and units 8-15 are operating modulo 8).

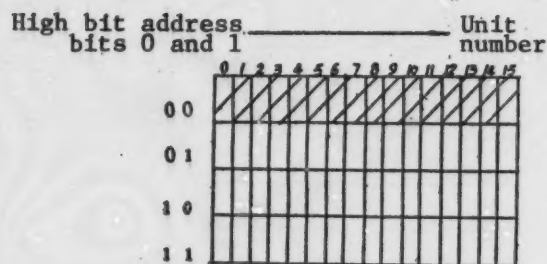


Figure 6. Logical Addresses in M4 + M8 Operation

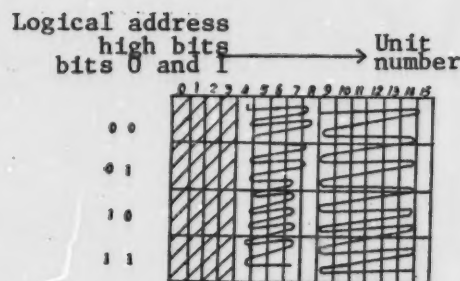


Figure 7. True Addresses in M4 + M8 Operation

When eight units are disconnected, the units in question are Nos 0-7, the capacity is decreased by $8 \times 32,768 \approx 260,000$. Only the final 260,000 logical address remain, and when the units 0-7 are disconnected the modified true addresses must be stored in units 8-15 operating modulo 8, as shown in Figures 8 and 9.

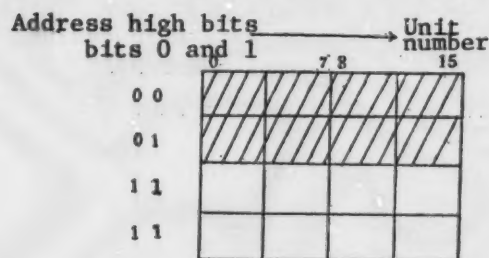


Figure 8. Logical Address in M8 Operation

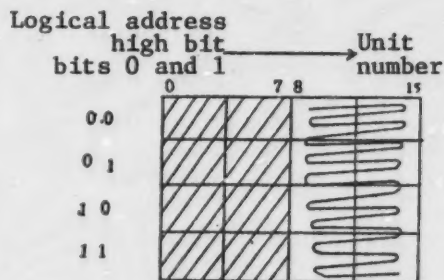


Figure 9. True Address in M8 (Units 0-7 disconnected)

When a unit is disconnected, the module number, the true addresses, the unit numbers and the address mapping are all implemented through memory control unit hardware. The amount of hardware required is not large, but it can increase machine reliability and memory unit availability. In general, with 16 memory units, an average of 1 unit a day malfunctions, and if it is replaced by a backup unit can be repaired within a day, the machine's speed and efficiency will not be degraded. Otherwise the unit must be disconnected and machine efficiency is temporarily degraded, but the machine can still operate normally.

To summarize, the 757 vector machine's memory control unit sees time-shared queuing, an overlapped pipeline, and bus operation; under present conditions these features, together with those described above, save hardware, increase speed and reliability, and have achieved rather good performance.

The 757's memory control unit was developed by collective effort; participants in the work included Comrades Yang Shufan [2799 2885 3058], Liu Pixuen [0491 0012 4821], and Wang Maojie [3769 5399 6738].

DESIGN CHARACTERISTICS OF 757 VECTOR MACHINE'S INSTRUCTION CONTROL UNIT

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[Text] The 757 machine is a large-scale high-speed computer system consisting of a peripheral processor and a mainframe (vector machine). This machine is made entirely with Chinese-made components and devices; the vector machine uses high-speed ECL [emitter coupled logic] small-scale integration [SSI], and some medium-scale integration [MSI] circuitry. The internal storage uses magnetic core memory. From the choice of the overall design approach through the logic design and engineering implementation, assuring machine reliability and operating speed was constantly a major concern. Several problems related to the design of the instruction control unit are discussed as follows.

I. Choice of the Instruction Control Unit's Mode of Operation

The 757 machine is a single-instruction-flow, multiple-data, serial-data-feed and serial-data-processing pipelined computer. The instruction flow, from the internal storage (NC) through the memory control unit (CK), the instruction control unit (ZK) and the operation controller and ALU [arithmetic-logic unit] (YI and YS), performs the process of instruction fetch, interpretation, and execution. One vector instruction can process a maximum of 16 numbers; when performing vector operations, 10 million results can be obtained every second; in scalar operations, between 2.5 and 3 million instructions can be processed per second.

The task of the instruction control unit is to fetch instructions from internal storage via the memory control unit, to decode operation instructions and compute their data addresses, and to decode and execute control instructions. The time (P beats per instruction) required for the instruction control unit to feed one instruction to the memory control unit and to the operation control unit and ALU may be in one of the following three relationships to the specified vector length W in the instruction:

- | | |
|---------|-----|
| $P = W$ | (1) |
| $P < W$ | (2) |
| $P > W$ | (3) |

The choice of P determines the mode of operation of the instruction control unit. If $P = 1$, it is best to use the pipelined mode of operation, with one instruction fed to the two other control units during each beat. When $P < W$, the analysis speed in the instruction control unit is faster than the instruction execution speed of the memory control unit and the operation control unit=ALU. At this point, the memory control unit and operation control unit can be provided with buffers for temporary storage of instructions which have been interpreted in advance by the instruction control unit, thus compensating for the fact that instructions cannot be fed to them in time because of blockage of the instruction control unit pipeline. If $P \geq 2$, it is best to use the beat control method, whose logic structure is simpler than that of pipelining. When P and S satisfy equations (1) and (2), the machine's operation is as described above. When P and S satisfy equation (3), the instruction control unit will be slower than the other control units and there will be a speed mismatch in the system. Many factors affect the magnitude of P ; the principal ones are the vector operation speed V_c , the scalar operation speed V_b , and the vector length in the instruction W :

$$P = f(V_c, V_b, W) \quad (4)$$

In the great majority of the 757's vector instructions, $W = 16$; when processing vector instructions, provided that $P < 16$ (which is very easy to achieve), the speed with which the instruction control unit interprets the instructions satisfies the requirements. Therefore, for a given W , V_b is the main factor in determining P .

Below, we select P for specified values of V_b . Assuming a machine cycle of $T = 100$ ns, when $V_b = 250 \times 10^4$ and 300×10^4 instructions/second, the values of P will be

$$P^* = \frac{1}{V_b \times T} = \frac{10^9}{250 \times 10^4 \times 100} = 4 \text{ beats/instruction} \quad (5)$$

$$P^* = \frac{1}{V_b \times T} = \frac{10^9}{300 \times 10^4 \times 100} \approx 3.3 \text{ beats/instruction}$$

If we choose $P = \lfloor P^* \rfloor = 3$, we obtain $V_b = 333 \times 10^4$ instructions/second.

Figure 1 is an instruction processing flowchart for $P = W = 3$. In this figure, F is the instruction fetch period, T is the time during which the instruction control unit is interpreting the instruction (includes instruction decoding and computation of the data address or execution), L is the time during which the instruction is being loaded, and E is the time during which the instruction is being executed. It is evident from the figure that once the machine has executed two instructions the pipeline is full and thereafter one result is obtained per beat. Naturally, the real instruction flow in the machine will be much more complicated than that shown in the figure.

Based on the above analysis, a beat operation mode in which the instruction control unit fetches an average of one instruction every three beats was adopted; typical operation is shown in Figure 2. M_0 - M_2 are the beat pulses,

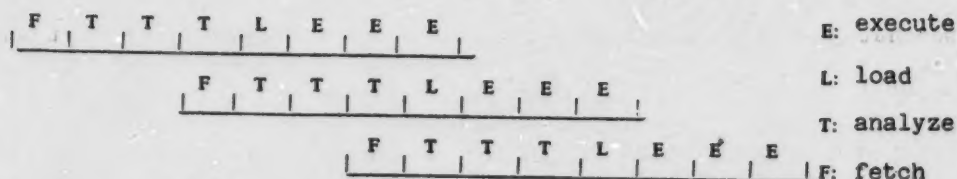


Figure 1. Instruction Processing Flowchart for $P = W = 3$

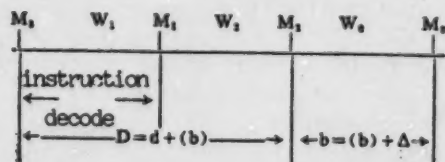


Figure 2. The Instruction Analysis

and W_0-W_2 are the beat control voltages. At M_0 the instruction interpreter loads an instruction from buffer ZH; during W_1 it decodes the instruction and begins to compute the data address, and at M_2 it obtains the logical address of the operand $D = d + (b)$. The next operand address, $b = (b) + \Delta$, is calculated during W_0 , and preparations are simultaneously made to fetch the next instruction. In the data address computation formula, d is the immediate operand from the instruction, and b represents the index register. The data address increment is $\Delta = l(bz)$, where l is the length of the vector, and bz is the increment storage location.

II. Design of the Instruction Dispatching Unit

The 757 vector machine uses magnetic core storage, which has a rather long read-write cycle; when modular addressing is used, if there is no access collision one unit of information is provided per beat. In order to decrease the demands upon internal storage and to assure that the ALU can process 10 million pieces of data per second, the instruction control is provided with instruction buffer storage ZH. When the ALU is not accessing internal storage, the instruction control unit can fetch additional instructions and store them temporarily in order to assure that when the ALU accesses memory, ZK [the instruction control unit] still will be able to provide a continuous flow of instructions and keep the pipeline operating smoothly. In designing the instruction dispatching unit, we were concerned primarily with the following two problems.

1. Choice of the Capacity of ZH [Instruction Buffer Storage]

In general, the greater the capacity of ZH, the smaller the demands on internal storage resulting from instruction dispatching. Naturally it would be best if the capacity of ZH were so great that it could hold an entire job program, but this is not feasible. In order to limit the amount of hardware used while not degrading machine efficiency, we had to make a statistical analysis of several problems, focusing primarily on branching.

Suppose that a branch instruction is stored in unit A and the target address of the branch is D. Then the dynamic statistics for this branch are as follows:

Let the branch distance be $\Delta = |D - A|$;
and suppose that the number of branches with $\Delta = 1$ is n_1 ;
the number of branches with $\Delta = 2$ is n_2 ;

$\vdots$

and the number of branches with $\Delta = m$ is n_m .

then the percentage of branches in which the distance is a given length is

$$S_i = \frac{n_i}{\sum_{j=1}^m n_j} \quad (6)$$

$$\text{and} \quad \sum_{i=1}^m S_i = 1 \quad (7)$$

We can use our computation results to plot S against Δ , as shown in Figure 3.

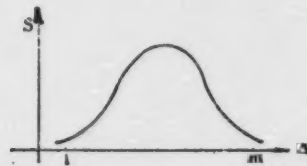


Figure 3. Plot of S vs Δ

For example, the statistical results for a large problem with PAF computation were

$$\begin{aligned} \text{when } \Delta = 32, \quad \sum_{i=1}^{32} S_i &= 50 \text{ percent} \\ \text{when } \Delta = 64, \quad \sum_{i=1}^{64} S_i &= 96 \text{ percent} \end{aligned} \quad (9)$$

In other words, when the capacity of ZH is 32 units, 50 percent of the branch instructions will branch to an address outside of ZH. If ZH has a capacity of 64 units, then only 4 percent of the branch instructions will go outside ZH's address space. This provides numerical data for deciding on a capacity for the instruction buffer.

2. Instruction Dispatching Strategy

In order to make full use of the storage space in ZH, we used several flexible instruction dispatching strategies in the instruction control unit. The principles on which these strategies are based were as follows.

(1) If there is vacant space in the instruction buffer storage, new instructions are dispatched into the vacant space. Because ZH has a large capacity, instructions fetched to the instruction register can be fetched from ZH.

(2) The space in ZH occupied by instructions which have already been executed is regarded as vacant, which assures that the next instructions in a sequential program will be continuously dispatched to ZH.

(3) The flag in a branch or loop instruction can be used to "fix" a program segment in ZH to assure high-efficiency transfer of loop programs.

To implement the above principles, we provided the instruction control unit with lower boundary address register xd , upper boundary address register sd , and control flip-flop CZY . Register xd contains the current starting address in ZH, and sd holds the address at which the current instruction dispatched to ZH is written (sd is incremented by 1 each time an instruction is dispatched). When $CZY = 1$, dispatching of instructions to ZH ceases.

Control over dispatching is exercised as follows:

(1) When the difference between sd and xd is less than 64, this indicates that ZH is not full, and instructions are dispatched into it.

(2) When the difference between instruction counter JSZ and xd is equal to or greater than 16, this indicates that at least 16 instructions that had been dispatched to ZH have been executed, so that there is room in ZH into which new instructions can be dispatched.

(3) When JSZ and sd are equal, this means that all of the instructions in ZH have been executed and more instructions can be dispatched to it. But under these conditions, if a loop termination instruction is the instruction currently being executed and the last pass through the loop has not yet been reached, because the instructions in ZH are a loop segment, no further instructions are dispatched to ZH.

(4) When the target address for initiating a job or a branch instruction is not stored in ZH, the contents of ZH are discarded and the starting address of the job or the target address is sent to xd and sd , while an instruction is simultaneously dispatched to ZH. In this case, when the first instruction is forwarded to ZH, it is simultaneously forwarded directly to the instruction register JZ for execution in order to speed up its interpretation and processing.

(5) When a loop opening instruction is being executed, if flag bit $T_2 = 1$, then the contents of JSZ is forwarded to xd . When a loop closing or branch

instruction is being executed, if flag bit $T_1 = 0$, then flip-flop CZY is set at 1 and dispatching of instructions is suspended. Flag bit T_2 can be used to "fix" a loop segment in ZH, while flag bit T_1 can be used to prevent instructions not currently being executed from being dispatched to ZH, which increases machine efficiency.

(6) When carrying out such instructions as transfer to the supervisor mode, setting of a switch, or end of computation, which change the machine state, the instructions previously dispatched to ZH are discarded and dispatching of instructions is begun again. Therefore, when such instructions are among those dispatched to ZH, CZY is set at 1 and the dispatching of new instructions to ZH is suspended.

III. Reliability Design of the Instruction Control Unit

The indicators of machine reliability include the following:

1. Average time of stable operation: for the 757's CPU, this is 50 hours.
2. Average machine utilization rate P:

$$P = \frac{\text{effective operating time}}{\text{effective operating time} + \text{maintenance time}} \quad (9)$$

Here by machine reliability, we mean the use of logic to decrease the machine repair time.

The faults which result in machine maintenance include solid faults and intermittent faults. A complete fault detection system includes fault notification, double calculation, and diagnosis. The objective of fault diagnosis is fault location, and it deals with solid faults. The objective of double calculation is fault-tolerant operation, and it deals with intermittent faults. The double calculation and diagnosis functions can improve machine reliability, availability, and serviceability (RAS). Below we discuss several topics related to fault detection hardware.

1. Set-up of Fault Detection Points

The fault detection points form a chained testing system; single faults and some multiple faults can be detected and announced during the current beat in any element of the instruction control unit. The fault detection algorithms differ from circuit to circuit.

- (1) Registers are all provided with parity bits and parity test circuits.
- (2) Parity prediction, setting of the parity bit, and parity testing are performed in the counters.
- (3) Matching of duplicated devices is used in the address adder.
- (4) Parity prediction and matching of duplicated devices are used in important control circuits.

2. Save the Fault State

When a fault message is emitted at a detection point, the fault state must be rigorously saved in order to allow the fault to be located. This requires that emission of the next pulse be stopped in the beat during which the fault is detected in order to prevent propagation of the fault.

Signal transmission in a logic circuit composed of D flip-flops can ultimately be simplified to transmission between a register, combinational logic circuitry, and another register as shown in Figure 4. The combinational circuitry in the figure includes the fault detection circuitry.

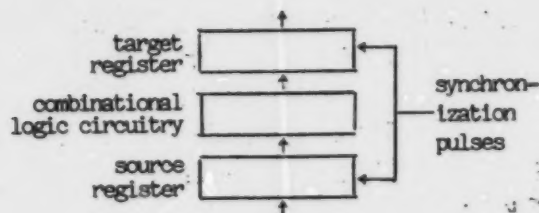


Figure 4. Signal Transmission Paths in Logic Circuitry Made Up of D Flip-Flops

In order to save the fault state, the following condition must be met:

$$T_s + T_c < T \quad (10)$$

where T_s is the time required for the signal to pass through the combinational logic circuitry, T_c is the time required for locking of the pulse, and T is the pulse cycle. Therefore, during the design process we imposed strict limitations on the lengths of all logic chains. In the debugging process we carried out an "alignment" of synchronizing pulses with reference to the actual chain length so that the instruction control unit could operate at a frequency 10 percent above the design value and the situation at the time of the fault could still be saved.

3. Recovery of the Fault Site

The instruction control unit is provided with a recovery register which can recover the conditions of the flags, registers and flip-flops and the important voltage levels at the time of the fault in order to allow the operator or the diagnostic program to locate the fault.

4. Double Calculation

The maintenance time in equation (9) includes the time needed to repair fixed faults and intermittent faults. Past experience indicates that in a large computer, intermittent faults are much more numerous (3:1) than permanent faults; their intermittent character makes them difficult to locate, which

presents great problems for maintenance and greatly lowers the computer's utilization rate P.

The basic concept of the double-calculation function is that the machine flow is temporarily stopped at the point of the failure; if the fault at this location is intermittent it may disappear spontaneously by the end of the pause, enabling the machine to continue operation. Double calculation is divided into program-level and instruction-level double calculation. The execution time in instruction-level double calculation is very short and is negligible in comparison with the maintenance time in solid faults; this fact greatly increases P.

The pipelines in the 757 machine are very long: when a fault occurs while the ALU is executing the K-th instruction, the instruction control unit may already be processing the K+7-th instruction. There may be several "destructive" instructions between the K-th and K+7-th instructions, and while the K-th instruction was being executed in the ALU, they will have already changed the contents of some registers or memory cells. Therefore it is pointless to have the instruction controller simply reload the K-th instruction and reexecute. For ease in selection of the point at which the double calculation begins, the 757 vector machine uses unified control by the double calculation software, with individual fault detection by the three control units at their respective interfaces, strict distinguishing of faults in different control units, and separate double calculation in each control unit. The instruction-level double calculation approach is used in the instruction control units. Below we discuss several problems related to double calculation.

1. Selection of Starting Point for Double-Calculation. The machine display of a fault site may be rather complicated, and if the fault site is used as the starting point for the double calculation, greater problems may result. A simple and effective method is to use the instruction in which the fault arose as the double calculation starting point. In this case it is only necessary to clear the instruction control unit and forward the instruction during which the fault occurred from the address specified in the double calculate instruction control register JSZ₁. The principal prerequisite for using the instruction during which the fault occurred as the double calculation starting point is that the program in internal storage be correct.

2. Distinguishing Double Calculable and Not-Double Calculable Faults. Because in certain instructions the contents of some register or memory cell may be altered at the end of a certain beat, if a fault occurs after this point to double-calculate is pointless. Therefore when designing the instruction control unit we made an analysis of the faults occurring at different beats in each instruction and determined which were double calculable faults and which were not; the relevant flags are either set or not set accordingly.

3. Choice of Double Calculation Control Process. When a double calculable fault has occurred, the instruction control unit must stop emitting pulses, save the current site, and notify the double calculation software of the

fault via the interrupt system so that the double calculation software can recover the current site, record it, clear the instruction control unit, dispatch the instruction to be double-calculated as specified by the contents of JSZ₁, and execute it. If no error occurs during execution of the double calculation of this instruction, only a "double calculation successful" interrupt signal is emitted, and the double calculation software is notified. If the double calculation is not successful, then the double-calculate software transfers control to the diagnostic software for fault diagnosis.

Both the structure cards and the control cards of the instruction control unit can send fault messages and diagnose and locate faults. If faults occur in important units on these cards, double calculation is still possible; and the extent of fault detection coverage is rather great. In a large computer, detection hardware generally accounts for about 25 to 30 percent of all hardware; it accounts for about 15 percent in the instruction control unit, and the amount of equipment used directly for double calculation is even smaller.

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LOGIC PARTITIONING OF 757 VECTOR COMPUTER INSTRUCTION CONTROL UNIT

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[Text] Logic partitioning of a computer constitutes the overall design activity in the computer engineering stage; it divides the entire machine's logic into levels and partitions it into small units which are easily laid out and replaced. The quality of logic partitioning affects machine speed and production cost, as well as reliability and maintainability.

The 757 vector machine is a large, high-speed pipelined computer. It is assembled from ECL small-scale integration [SSI] and some medium-scale integration [MSI] circuitry and its logic is partitioned in three levels: frame, board, and card. In the past, logic partitioning was pieced together based on the experience of the engineering and technical personnel and their familiarity with machine logic; there were no general rules on which to rely. This meant that in the case of the third logic level, and particularly in the case of the control cards, because of their logical complexity, chaotic arrangement and size and the fact that they had always required the most iterations and were the most time-consuming components in computer engineering, logic partitioning was a major factor affecting the quality of the computer. When partitioning the 757 vector machine's control cards, we produced a mathematical description of the logic partitioning on the basis of logic diagrams and bipartite graphs, and used network connection matrices and tables to partition the logic; this approach achieved good results, while not only decreasing the time spent and reducing the number of iterations, but also producing a rather rational partitioning and providing experience for the automation of partitioning.

I. Mathematical Description of Logic Partitioning

Logic partitioning begins with logic diagrams and engineering specifications. Once logic diagrams are expressed in terms of equivalent bipartite G graphs, the logic elements distinguished in the partitioning, such as boards and cards, must satisfy the G graph node union and intersection equation (1) in logical terms and also must satisfy the equation (2) regarding space for the elements and their internal connections in engineering terms:

$$\left. \begin{aligned}
 &\bigcup_{i=1}^n H_i = H \\
 &H_i \cap H_j = \emptyset \quad (\emptyset \text{ is the null set, } i \neq j) \\
 &K(H_i) = \sum_{a \in H_i} K(a) \leq K_{\max}
 \end{aligned} \right\} \quad (1)$$

$$\left. \begin{aligned}
 &p(H_i) = \sum_{a \in H_i} p(a) - \sum_{s \in I(H_i)} d(s) - \sum_{s \in B(H_i)} (d(s) - 1) \leq p_{\max}
 \end{aligned} \right\} \quad (2)$$

H in equation (1) is the node set of the G graph, and H_i and H_j are two subsets of H . In the partitioning of levels 1 and 2, these subsets represent the frame and board. When we discuss the partitioning of the instruction control unit's control cards, H_i and H_j refer to cards. For example, the look-ahead station distributor diagrammed in Figure 1(a) is a logical network consisting of nine logic elements (a_1 - a_9 , of which five are flip-flops, three are gates and one is a half-adder), whose equivalent G graph, shown in Figure 1(b), includes nine circuit nodes formed by logic elements (a_1 - a_9), nine boundary signal nodes (S_1 - S_9) formed by networks, and four internal signal nodes (S_{10} - S_{13}). H in Figure 1 is the set of the a_i 's and S_i 's, while H_i is a set consisting of some of these nodes. Thus equation (1) includes two meanings: 1) the nodes in the G graph for the control logic of the instruction control unit must be the totality of the nodes on the control cards, and no logic must be omitted; and 2) the nodes on the control cards do not overlap, i.e., after partitioning, logic is not duplicated.

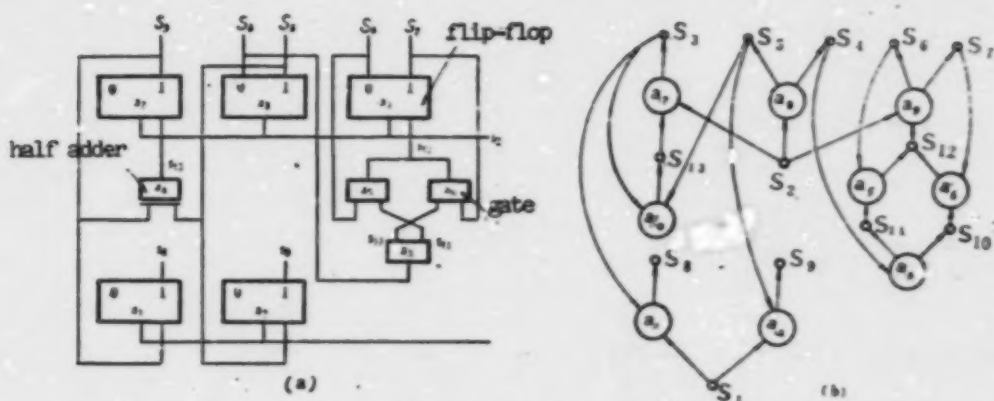


Figure 1. Distributor of Look-ahead Station
 (a) Logic diagram;
 (b) Logic diagram bipartite graph G

The first formula of equations (2) states that the number of [integrated circuit] packages partitioned onto a card must not exceed the permitted layout number $K_{\max}$. $K(a)$ in the equation denotes the number of packages used in logic element a_i . If the look-ahead station distributor shown in Figure 1

is partitioned onto a single card, and if one IC package represents one logic element, then the card will have nine IC's. The type A cards in the 757 vector machine can hold 78 IC's and the type B cards 48. Since the instruction control unit's control cards are type A cards, we choose $K_{\max} = 78$. The second formula of equations (2) gives the card connection factor and states that the number of card pins used must not exceed the permitted number $P_{\max}$. The first term in the equation gives the number of internal connections in the set of logic elements, the second term gives the number of connections between internal signal nodes, and the final term gives the number of connections of the set of boundary signal nodes. Because the number of external connecting lines in Figure 1 is 28, the number of internal signal node connections 9, and the number of boundary signal node connections 10, when the logic of Figure 1' is partitioned onto a single card, the number of pins used is $9 = 28 - 9 - 10$. Since the instruction control unit is on a type A card, we have $P_{\max} = 108$ lines. The maximum number of external connection lines for a type A card is $\sum_{a \in H_1} p(a) = 1100$ lines.

II. Criteria of the Feasibility of Partitioning of an Instruction Control Unit Control Card

Whether a partitioning of a card is feasible depends primarily on whether the number of IC packages used exceeds $K_{\max}$, whether the number of pins used exceeds $P_{\max}$, whether the logic chains on the card are within the specified speed range, whether the loads of the drivers on the cards are within the specified range, and whether the wiring on the card exceeds the specified number of connections. In general, if a card meets the above five specifications the partitioning is feasible. Naturally, a feasible partitioning is not necessarily optimal or even good. Therefore, to these five basic criteria we add several quality criteria for partitioning. Below we list the feasibility criteria for instruction control unit control cards.

1. The maximum number of IC packages $K_{\max}$ per card is 78.
2. The maximum number of pins per card $P_{\max}$ is 108.
3. The maximum number of transmission levels per logic chain is $L = 23.5$, including 17.5 logic levels and 6 levels worth of 3-meter transmission line delay.
4. The maximum number of connection wires per card is $\sum_{a \in H_1} p(a) = 1100$ lines.
5. The maximum load on the drivers is $G = 8$. If loads on another card are driven, they must all be limited onto the same card.
6. The gate-to-pin (or package-to-pin) ratio $\xi \geq 0.5$. This is an aggregate indicator of the space factor and the external connection factor for the cards. The greater ξ is, the better the card is partitioned.
7. The minimum number of IC packages per card $K_{\min} = 20$. Because ξ is a ratio, it may be large without the cards being filled by IC's. Therefore,

a card can only be regarded as effectively partitioned when a minimum number of IC's per card is specified and ξ is large. But it must be borne in mind that because there are several gates (or logic units) per card, when the gate utilization factor is not high, even if ξ is large the real gate-to-pin ratio will still not be large.

8. The values of the elements A_{ij} of the A matrix in the initial state must be no greater than 20 in order to assure the quality of the card type subgroups.

9. One logic element must be and may only be partitioned onto a single card. This is in order to prevent duplications and omissions. When the nodes have different names, this requirement will naturally be satisfied during partitioning.

The partitioning feasibility criteria are the constraints on logic partitioning. In this sense, logic partitioning is a problem of finding an assembly algorithm which will satisfy the various constraints. If the requirements regarding card partitioning are extremely stringent, the feasibility criteria will of course be numerous, the assembly conditions will be complex and some of the factors will be mutually exclusive, so that logic partitioning will unavoidably be an iterative process involving continual revision.

Nine criteria have been specified for partitioning the instruction control unit's control cards. In order to simplify the problem and decrease the number of calculations, certain engineering requirements, such as a high IC utilization rate, the placement of IC's on the cards and the like were not taken into consideration.

III. Logic Functional Groups and Card Type Subgroups

1. Logic Functional Groups

The control logic of medium and small computers is relatively simple, and in order to decrease the number of card types, standard cards with relatively low values of ξ are used. But in large, high-speed computers this method will greatly increase the number of cards and may degrade machine speed. The control logic of the 757 vector machine's instruction control unit is implemented with specialized cards, of a large number of types; these make up nearly half the instruction control unit. Naturally, the attempt to achieve a high gate-to-pin ratio in logic partitioning becomes extremely important.

An effective means of increasing ξ is to group the logic elements in terms of logic functions and to place logic units belonging to the same functional group on the same card so that the networks connecting the logic elements can be contained within the card. The control logic functional groups in the instruction control unit were determined on the basis of the structural logic layout, the internal connections of the logic, and the requirement that the functional groups satisfy equation (2). The instruction control

unit's function includes more than 3,500 logic elements, which were grouped into 97 functional groups; these groups were then treated as the basic elements in card partitioning.

2. Card Type Subgroups

These groups are the nucleus of the card and are the functional groups that are distributed among the cards at the outset. The type subgroups, denoted a_1 , are selected from the functional groups, and the remaining functional groups are denoted a'_1 . The principles that were observed in selecting subgroups for the instruction control unit's control cards were as follows.

The a_1 's are surrounded by a specific number of closely interrelated logic functional groups, and the logical relationships between the a_1 's are as loose as possible; the number of a_1 's may be large or small. Based on the structural logic layout of the instruction control unit, we chose 32 a_1 's as card type subgroups and specified that one type subgroup would be used per card.

Once the partitioned logic was organized into functional groups or type subgroups, the logic partitioning was still described by equations (1) and (2), but the a 's in the equations no longer denoted simply logic elements, but instead denoted logic functional groups or type subgroups; the nodes on the G graphs were also calculated in terms of functional groups.

IV. Partitioning of the Instruction Control Unit's Control Cards

When partitioning the instruction control unit's control cards, equation (1) was implemented in terms of a network connection matrix, and equation (2) in terms of a table of the a_1 's and a logic distribution table for the b_1 's and a_1 's. As shown in Figure 2, the matrix and the tables are used to cross-check each other.

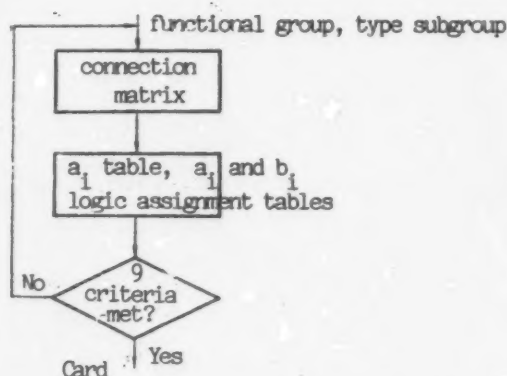


Figure 2. Relationship Between Matrix and Table

$$C = \begin{matrix} & a_1 & a_2 & \dots & a_{32} \\ \begin{matrix} a_1 \\ a_2 \\ \vdots \\ a_{32} \\ \hline a'_{33} \\ a'_{34} \\ \vdots \\ a'_{97} \end{matrix} & \begin{pmatrix} A \\ \hline B \end{pmatrix} \end{matrix}$$

(3)

1. The Network Connection Matrix

The network connection matrix based on equation (1) describes the connections between different type subgroups and between type subgroups and functional groups. Matrix calculations can be used to decide the allocation of the functional groups and to test the quality of type subgroup selection. The form of the connection matrix used in partitioning the instruction control unit's control cards is shown in Figure 2.

The rows $a_1, a_2, \dots, a_{32}$ in the matrix represent the 32 type subgroups, while the columns represent the 32 type subgroups and the 65 functional groups that are to be allocated. The matrix includes submatrices A and B. Elements A_{ij} of matrix A express the connections between different functional groups, while the elements B_{ij} of matrix B express the connections between the functional groups which are to be allocated and the type subgroups. The connections between the a_i and a_j and between the a_i and a'_j (also denoted a_j in the table) are described by the following two equations:

$$c_{ii}(a_i, a_j) = |B(a_i) \cap B(a_j)| \quad (4)$$

$$d_{ii}(a_i, a_j) = |B(a_i) \cup B(a_j)| - c_{ii}(a_i, a_j) \quad (5)$$

$$(i=1, 2, \dots, 32, j=1, 2, \dots, 97, i \neq j)$$

In the equation $B(a_i)$ are the boundary signal nodes of the type subgroups, while $B(a_j)$ are the boundary signal nodes of the functional groups. Equation (4) expresses the connections between the a_i 's and a_j 's, while equation (5) indicates the absence of connections between the a_i 's and a_j 's. If $d_{is}(a_i, a_j)$ is the result of the final card partitioning operation, this $d_{is}(a_i, a_j)$ is also the actual number of pins used on the card.

During the partitioning process, the matrices are continually changing, the $a'_{33} - a'_{97}$ are continually being combined and reduced, and the content of $a_1 - a_{32}$ is also continually changing. The initial state of matrix A expresses the interconnections between the type subgroups, and the sparseness of the matrix and the magnitudes of the A_{ij} 's indicate how well the type subgroups have been chosen. In other words, the sparser the matrix and the smaller the values of the A_{ij} 's, the smaller the number of logical relationships between the type subgroups and the better the choice of the logic subgroups. Ideally, all of the A_{ij} 's should be zero, but this is unattainable, and in the design process we specified $A_{ij} \leq 20$.

Matrix B expresses the relationships between the functional groups which are to be allocated and the type subgroups. Assuming that one type subgroup is placed on one card, matrix B expresses the card state during the logic partitioning process. When the elements of a row in the matrix are all zeroes, then there are no logical connections between the functional groups to be allocated and the card of which the type subgroups represented by the column are the nucleus. In other words, the partitioning of this card is complete and it can be removed from the matrix. When the elements of a line in the matrix are all zeroes, there are no logical connections between the functional groups represented by this line and any cards; but they may still have logical connections with other subgroups, so that when the row is removed from the matrix a new matrix can be formed, constituting a new card.

2. The a_i Card Characteristic Table and the b_i and a_i Logic Allocation Tables

The a_i card characteristic table (Table 1) records the characteristics of the card type subgroups and the characteristics of each card after the matrix computation. The characteristics recorded contain $d_{is}(a_i, a_j)$, $K(a)$, L , and G . There are large numbers of L 's and G 's, and these need not all be included in the table. The L 's and G 's that are included in the table are the engineering logic levels of the external leads and the driver loads. Once card partitioning is completed, the final characteristics in the table should be tested in terms of ξ . If they meet the specifications, the card may be used, but if they do not, the card must be assembled and partitioned again. Generally, the type subgroups on such a card are changed into functional groups and a new selection must be made for partitioning. As a rule, K_{max} , K_{min} , the transmission speed and the load have been checked in the process of entering the $K(a)$, L , and G .

When matrix B is used in laying out the logic, there are always rows and columns that are not all zeroes. When the row elements are not all zeroes (but more than one is), there is a logical connection between one of the functional groups to be assigned and several cards, and this functional group may be assigned to any of several cards. When the column elements are not all zeroes (but more than one is), there are logical connections between several functional groups and one card, and these functional groups may be combined on a single card. In the former case the logic is laid out by means of a b_i table in the latter case the a_i table is used.

The b_i logic allocation table (Table 2) records the initial number of external leads and of IC packages of the functional groups to be allocated, as well as the number of external leads and the maximum values of L and G after logic allocation to the a_i cards. This indicates to which a_i cards they are best assigned. The a_i logic assignment table determines which functional groups can be combined on a given a_i card. Because some of the functional groups that have been combined on a card have close connections with the a_i card and some functional groups have close connections between each other, the number of IC packages in these groups and their number of leads will differ. In this case, an assignment of functional groups to the a_i cards which maximizes ξ while the other characteristics meet the specifications should be chosen.

Table 1. a_1 Table

K(a)	Type subgroup					First assembly					...
	Level, load			K(a)	dis	Level, load			K(a)	dis	
	L ₁	G ₁	...			L ₁	G ₁	...			
a ₁											
a ₂											
...											
a ₃₅											

Table 2. b_1 Logic Allocation Table

	K(a)	dis	a_1			a_2			...	a_{35}		
			dis	L	G	dis	L	G		dis	L	G
a'_{35}												
a'_{33}												
$\vdots$												
a'_{27}												

Table 3. Logic Assignment Table for a_5

	a' assembly	K(a)	$C_{..}$	a_{is}	ξ
1	5,6	15	0	x	x
	5,6,9	25	x	x	x
	5,6,9,18	34	x	x	x
2	5,9	17	12	6	2.84
	5,9,18	26	17	8	3.25
3	5,18	16	2	20	0.8
4	6,9	16	10	13	1.38
	6,9,18	18	16	8	3.37
5	6,18	27	0	0	0
6	9,18	19	5	10	1.9

The a_1 logic assignment table is not large: Table 3 is a table that was used in partitioning the instruction control unit's control cards. It can be seen that when partitioning card a_5 , groups a'_5 , a'_6 , a'_9 , and a'_{18} were logically connected with this card. We now distinguish six circumstances in assembling the card. The number of IC packages, the connection characteristics (c_{on} and d_{is}), and the values of ξ are entered in the table. In the first assembly version, because there are no logical connections between a'_5 and a'_6 ($c_{on} = 0$), the two following assemblies (a'_5 , a'_6 , a'_9 , and $a'_5 a'_6 a'_9 a'_{18}$) are also not computed again (indicated by X's in the table); in the other five assembly versions the functional groups are all interconnected, and case 2 of assembly version 4 is the best; therefore we decided to place functional groups a'_6 , a'_9 , and a'_{18} on card a_5 . The a_1 table tells whether they meet the requirements regarding K_{max} , K_{min} , L, and G.

Because in matrix B, rows which are not all zeroes and columns which are not all zeroes occur simultaneously, the question of whether to use the b_1 logic assignment table or the a_1 logic assignment table is a matter to which particular care is paid. If the b_1 table is used, functional groups with only

slight logical connections may occur together on the same card, while if the a_1 logic assignment table is used, functional groups with only slight logical connections to the a_1 cards may be included on the cards. Thus each approach has its advantages and disadvantages. Naturally the best method is to carry out several test computations, but in general it is better to use the b_1 table, because it requires fewer computations.

C. Partitioning Flowchart for the Instruction Control Unit Control Cards

The instruction control unit control cards were partitioned in accordance with the flowchart in Figure 3. This chart is divided into three sections. In the first section, the G graph is drawn and the logic functional groups are partitioned in accordance with the logic diagrams and engineering specifications. In the second section the type subgroups are selected from the functional groups, A-matrix calculations are made, and the type subgroups which do not meet requirements ($A_{11} \leq 20$) are rejected and are reclassified as functional groups. The third section includes B-matrix calculations and the making of the a_1 tables and b_1 and a_1 logic assignment tables. Functional subgroups for which the matrix columns are all zeroes are reclassified as type subgroups, and the a_1 cards are checked in terms of the partitioning feasibility criteria. The cards which do not meet these requirements must be repartitioned, while those which do meet the requirements are handled in one of two ways. The cards in which some columns are all zeroes are not included in the partitioning, while those in which the column elements are not all zeroes are subjected to further logic assignment.

The instruction control unit's control logic was ultimately partitioned onto 30 card types (i.e., onto some of the cards included in logic partitioning). The average number of IC packages per card type was over 55 and ξ was equal to or greater than 0.61, with a maximum of 1.14. In order to decrease the number of assembly iterations and the amount of computation, the logic that was left over at the end was assembled in ad hoc fashion on one card, which contained only 33 IC's and had a ξ value of only 0.31, indicating rather poor quality.

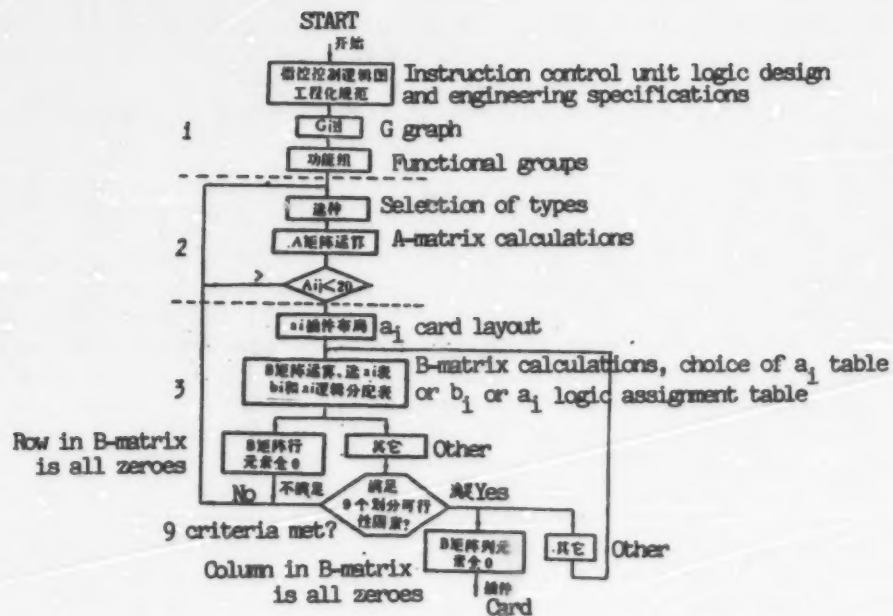


Figure 3. Flowchart for Partitioning of Control Cards of Instruction Control Unit

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INTRODUCTION TO 757'S PERIPHERAL PROCESSOR

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 2, 1984 pp 44-48

[Article by Mei Duolun [2734 1122 0243], Institute of Computing Technology, Chinese Academy of Sciences]

[Text] What role does the 757's peripheral processor play in the system? How is it related to the vector processor? How do the two machines communicate? What are the characteristics of the way in which the peripheral processor is connected to the peripheral devices, and what is its machine language like? Below we summarize certain major topics regarding the peripheral processor.

I. Why Does the 757 Adopt the Peripheral Processor Scheme?

The vector processor is good at long vector calculations. Its efficiency can be effectively used in solving problems with a high degree of parallelism; but the efficiency of the vector processor will be lowered by problems with large numbers of scalar computations. But the computer's system programs involve principally scalar operations, and accordingly we considered using a peripheral processor to handle this time-consuming, repetitious work.

In addition, pipelining was used to implement high-speed vector computation. For the pipeline to operate smoothly, it is also desirable to have few interrupts and branch instructions. The system programs have a relatively large number of branch instructions, and accordingly it is advantageous to relegate these programs to a peripheral processor.

Having the peripheral devices directly controlled by the peripheral processor rather than connecting them directly to the vector processor decreases the number of interruptions of the latter, which also decreases the number of interruptions in the pipeline. In short, the peripheral processor approach was used in order to take advantage of the efficiency of the 757 vector processor.

II. Tasks of the Peripheral Processor

The peripheral processor, the principal link between the central and peripheral components of the 757 system, carries out system control functions.

Its specific tasks are: compilation of high-level language and assembly language, control of the entire system through the operating system (including task scheduling, resource management, I/O [input/output] data processing, I/O device control, man-machine interfacing and the like); and diagnosis of the vector processor.

III. Communication Between Machines

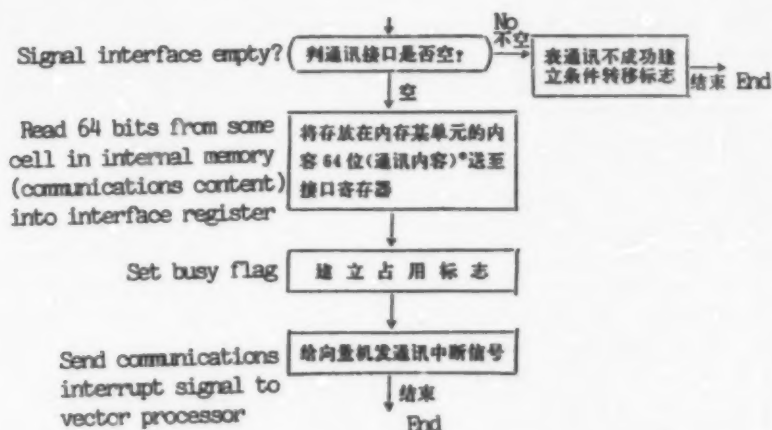
Since the peripheral processor, the vector processor, and the peripheral devices operate under the centralized control of the operating system, the machines must be able to communicate with each other and to exchange the information which they contain.

There are three specific ways in which the machines communicate information.

(1) Direct notification: When a fatal hardware fault develops in one machine, it immediately emits an emergency interrupt signal to the other machine.

(2) Communication: In order to meet the requirement for conversation between two machines, specialized interface equipment is provided. The vector and peripheral processor have their respective communication instructions, and when necessary each can use these instructions to initiate communication with the other.

The peripheral processor has two communication instructions. To initiate communication with the other machine, the "communication out" instruction is used. Its functioning is shown in the figure.



When the vector processor initiates communication with the peripheral processor, it also uses the interrupt method. When the peripheral processor responds and processes this interrupt, it must use the "communication in" instruction, whose function is to take the contents of the communications interface input register and transfer them to the internal storage cell

specified in the instruction. If they are correctly transmitted without error, the interface release signal is emitted, while if there is an error in the transmission, an interface error interrupt is sent. As can readily be imagined, the vector processor has two analogous instructions.

(3) Batch information exchange between the vector processor and the peripheral processor: The peripheral processor and vector processor do not share internal storage, and accordingly a channel for batch information transmission is required. For the peripheral processor, exchanging a batch of information with the vector processor is analogous to exchanging a batch of information with a peripheral device, and this interface is treated as one of 32 subchannels. The peripheral devices can be started or stopped only by the peripheral processor. The interface for batch transmission between these devices also can be started only by the peripheral processor.

In order to provide reserve capacity, the 757 system also can be equipped with an additional processor, called peripheral processor No 2, which is connected to the first peripheral processor just as the latter is connected to the vector processor. In addition, between the two peripheral processors there is a communication interface, a data transmission interface, and emergency notification, which we will not describe in detail here.

IV. Relationship of the Peripheral Processor to the Peripheral Devices

1. Survey of the Channels

All peripheral devices of the 757 system operate under the control of the peripheral processor. Of a total of 32 subchannels, 27 are in use and 5 are backup channels. In order to lighten the load on the peripheral processor and to allow it to handle information from the vector processor more rapidly, the eight subchannels for disk and tape units, an electrostatic printer, and a graphic display unit can also exchange data directly with the vector processor's internal store. In addition, they are divided into two direct paths to the vector processor's internal store. These direct-access channels also operate under the control of the peripheral processor. The peripheral processor is connected to the various peripheral device controllers by a channel controller, which controls the priorities of the various subchannels and the transmission of batches of data by each. When transmission of a batch of data has been completed, a completion interrupt is sent to the peripheral processor; thus the channel control word lacks a "zipper capability."

In addition, in order to meet speed requirements and provide direct access to the vector processor, the disk and tape units, the electrostatic printer, and the graphic display unit are also provided with controllers, which are generally called "disk-tape controllers." The data paths are shown in Figure 1.

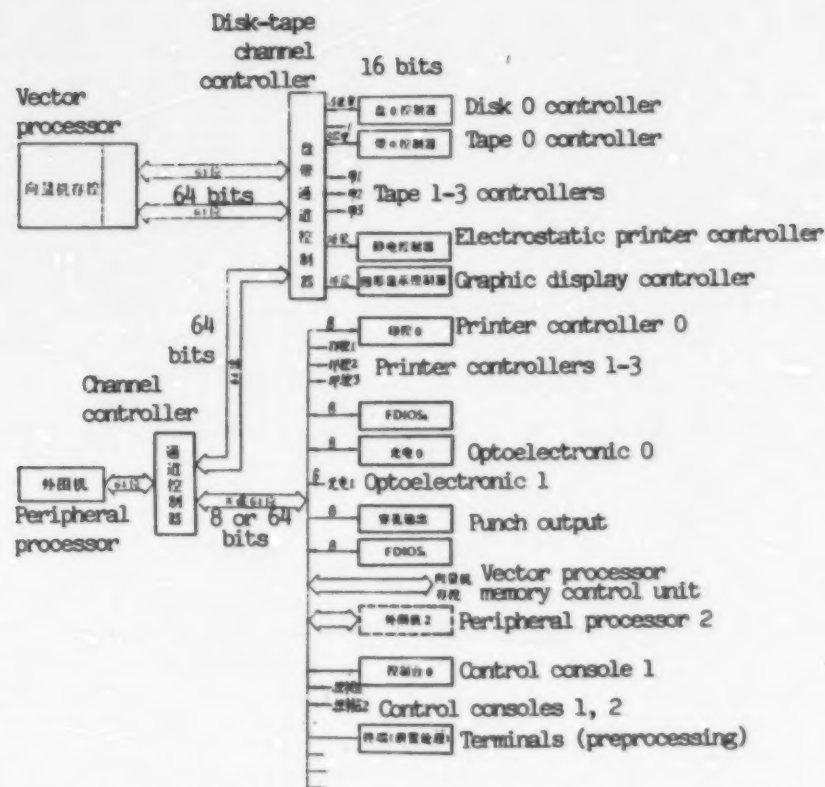


Figure 1. Schematic Diagram of the 757 Data Paths

2. How the Peripherals Are Used

No matter what the internal and external connections are, the supervisor program must send out a group of basic information for use of the peripheral devices. This information includes the internal storage starting address (for input, the storage of the information coming from outside begins at this address; for output, the information is sent starting with this address), the exchange length, the channel number, and the device number; in addition if a device operating code is to be exchanged with external storage, the external device address must also be specified. Different devices send this information in different forms.

The 757 peripheral processor lacks specialized peripheral device instructions; a register is provided for each category of information. Currently nine register addresses can be specified on each subchannel. Fewer are used in some subchannels. Then ordinary load and move instructions are used to access these registers, which is just as convenient as accessing an internal storage cell. Peripheral device operation is controlled by the contents of the registers. This type of connection and utilization provide flexibility and convenience for future expansion of the suite of peripherals.

V. Cross-Connected Channels

For the sake of reliability, the eight disk units are cross-connected into two subchannels. As the system diagram shows, if one channel malfunctions and cannot be used, all disk units can be accessed via the other subchannel, although the information transmission rate will naturally fall. The likelihood of both subchannels being inoperable simultaneously is small.

There are four magnetic tape drive subchannels: They are D_0 , D_1 , D_2 , and D_3 . D_0 and D_1 can be connected to eight tape drives between them; D_2 and D_3 also can be connected to eight tape drives between them, for the sake of reliability.

To enable the disk and tape units, electrostatic printer, and graphic display unit to directly exchange information with the vector processor's internal storage, two direct access channels are provided. Eight channels are used, with the odd-numbered and even-numbered subchannels forming groups. The provision of two direct-access channels is also for the sake of reliability: if one fails, the other can still be used to access all of the disk and tape drives. Under normal conditions the direct-access channels operate in parallel with high efficiency.

The direct access channels also operate under the control of the peripheral processor, which sends out peripheral device operating instructions, processes interrupt requests for the peripheral device controller and the channels, and recovers channel states.

Each of the eight subchannels connected to the two direct-access channels can individually exchange information with the peripheral processor's internal storage. But how is it possible to distinguish whether the peripheral device is exchanging information with the vector processor or the peripheral processor? Actually, the command word sent out by the peripheral processor contains a distinguishing flag.

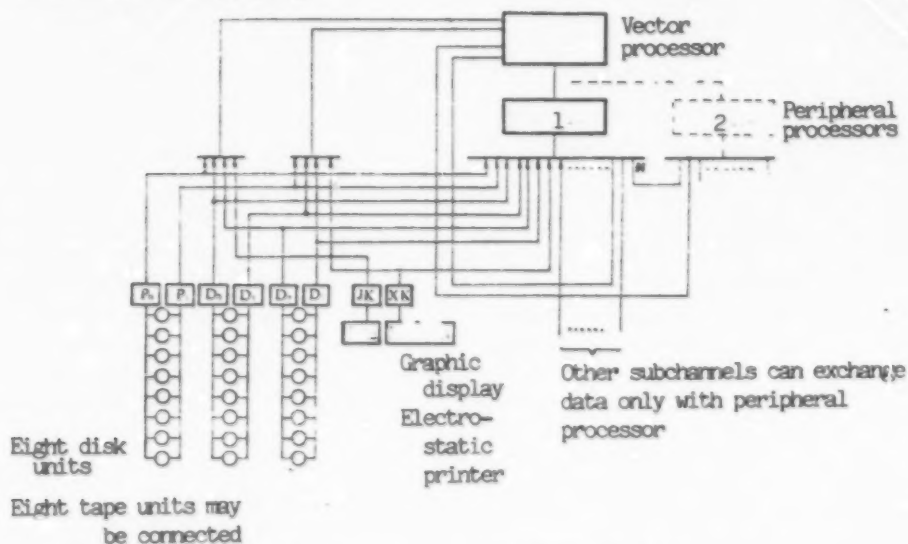


Figure 2. Block Diagram of the 757 System

VI. Capacity, Characteristics, and Reserve Capacity of the Peripheral Processor

The capacity of the peripheral processor is related to its tasks, the number of varieties of peripheral devices, and the capabilities of the operating system. Since this is the first design approach using a peripheral processor, there are as yet no statistics, so that we simply defined the capacity and specifications of the peripheral processor in terms of an analysis of likely situations. (1) The word length is 64 bits, using a fixed point binary complement system. Each memory cell contains two instructions with a single-address format. (2) The main frequency is 2.5 MHz and the average speed is 500,000 MIPS. (3) Storage: (a) 64,000 words of core storage with a cycle of 1.6 μ s and with Hamming error detection. (b) Semiconductor storage of 64,512 words with a read time of 600 ns, using parity code. (c) Fast semiconductor storage, with a cycle time of 100 ns and a read time of 40 ns. The peripheral processor has a total of three semiconductor storages: the page table storage, the index storage, and the channel control storage.

Since it was not known whether this capacity would be sufficient, the possibility of installing a second peripheral processor was provided for in order to add extra capacity (see Figure 2).

VII. Instruction Format and Instruction Set

Principal data formats: character strings, integers, various table formats.

Instruction format: it is desirable for the instruction format to be simple, complete, and convenient to use and to recall, because assembly language is still used to write other system programs.

1. Basic instruction type:

where 0 is the opcode;

0	5	6	7	8	9	10	13	14	31
0	t	f	b	d					

b is the index storage cell address ($b = 1, 2, \dots, 15$), $(b_0) \neq 0$,

d is the formal address;

f is the formal address mode flag bit:

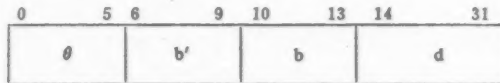
f = 0: $(b) + d = D$, where D is an 18-bit opcode (immediate addressing mode);

f = 1: $(b) + d = D$, where D is a logical address. In non-core-storage programs, it is generally necessary to refer to the page lookup table to convert it to a real internal storage address;

f = 3: $(b) + d = D$, where D is also a logical address; and $b + 2 \rightarrow b$, the self-incrementing mode; f = 3: $(b) + d = D$, where D is a logical address, and $(b) - 2 \rightarrow b$, the self-decrementing mode.

t is a flag bit, whose meaning varies with the instruction type.

2. Indexed jump type: differs only slightly from type 1. The t and f fields are combined into a b' field. In an index type instruction, b' is the target address of the index unit, while in a branch instruction b can be used to save the return address or as a stack pointer indicating the saved return address:



Instruction set. The guiding concept was to keep it general with some special emphases, and when feasible to strengthen instruction capabilities as much as possible and to increase the execution efficiency of typical program segments. "Keeping it general" means use of ordinary general-purpose instructions, while "special emphases" refers to the fact that since the peripheral processor's primary task is to execute system programs, it has some special characteristics that distinguish it from ordinary large general-purpose computers. The system software characteristics are as follows.

It has different data formats. The peripheral processor functions primarily with integers and character strings and tables, while large general-purpose computers generally deal primarily with the floating point format. General-purpose computers solve numerical problems and generally work from equation to equation, using a relatively high proportion of arithmetic instructions, while system software generally moves from one table to another. Its processing activity characteristically involves table lookup, table creation, classification, and aggregation. For example, the operating system generally uses a variety of tables for the purpose of system management. When a new job is entered, for example, the operating system must fill out the "job backlog register." This is a table creation process. In high level scheduling procedures, selection of jobs from the job backlog register requires table lookup. As another example, when the user enters information as a file, the file management program sets up a file for the purpose, which is also table creation; and utilization of this file requires table lookup.

The compilation process is also a table lookup process, in which the original program can be regarded as a table composed of characters, and the various tables, such as the alteration pointer tables, name characteristic tables, and the like are used in various passes until a table in machine language, i.e., the object program, is produced. These requirements make the following features desirable.

(1) There should be flexible data load and store instructions. To provide for this requirement the 757 peripheral processor has: (a) standard load and store instructions for full word length data; (b) load and store of a bit or bit string in any position; (c) load and store of a field of any length within a memory cell; (d) use of immediate data. Computations with integers smaller than 2^{18} are more conveniently handled with immediate data. Its advantage is that it saves memory space and makes program inspection more informative. The immediate data format is generally used in address calculation and character recognition.

(2) Strengthening of instruction capabilities where possible in order to increase program execution efficiency. Naturally the basic capabilities should be drawn from large numbers of programs that are commonly run. For example, in the initial scan program of a compiler, to load each character, initially a "character-by-character load" subroutine was written. The way this subroutine worked was that each time it was entered, one character was loaded into the lower eight bits of the accumulator and a position was prepared for the next character by determining the memory cell in which it would be located and the byte number. This subroutine took about 10 instructions. But since it was a subroutine, on each entry it was necessary to execute two supplementary instructions (branch and return). The 757's peripheral processor uses a machine instruction to replace the functions of this subroutine.

The "load character" instruction works as follows: Memory unit i is loaded from main memory; the j -th character enters the lower eight bits of the ALU, while at the same time a location is prepared for the next character to be loaded in accordance with the particular circumstances. There are generally four cases:

- ① Only one character is loaded, so that there is no need to prepare for the next character;
- ② The next character to be loaded is the same as the present character, i.e., there is no alternation in i and j (successor operation not necessary in instruction);
- ③ The next character is chosen in order, but it suffices to specify the successor operation. When $t = 2$, the successor operation specifies that $J = J + 1$. If $J = 0$ the character to be fetched is in the next memory cell, and in this case the hardware sets $I = I + 1$. I is the index element in the instruction. J is a three-bit byte register.
- ④ The character to be fetched next is fetched in reverse order, in which case the decrement flag in the instruction is used. Thus, after a specific character is fetched, if $t = 3$, then $J = J - 1$, and if, for example, $J = 7$, the next character to be fetched is in the preceding memory cell; in this case the change $I = I - 1$ is automatically made.

It should be made clear that before the character is fetched, the initial value is loaded into J ; in sequential scanning, after this initial transfer all the operations are made automatically.

Corresponding to "load character" is "store character." Its function is to send the character in the accumulator to the j -th byte position in the i -th memory unit of internal storage, while all other character positions are unchanged. The alternations of i and j are the same as for "load character" and will not be described in detail here.

As another example, in order to replace units in page storage more rapidly, the peripheral processor is provided with a "store page" instruction. The

functions of the instruction are flexible, and four page units can be stored each time the instruction is executed.

(3) In order to solve synchronization and collision problems in the operating system, the P and V operations are used. These two operations can be implemented via two subroutines executed in the locked condition. Two instructions are used to carry them out in the peripheral processor: if the signal value is stored in D, the P operation is $(D) - 1 \rightarrow D$, $D \rightarrow$ miscellaneous register, and when $(D)^* < 0$, it produces an interrupt; the V operation is $(D) + 1 \rightarrow D$, $D \rightarrow$ miscellaneous register, and when $(D)^* \leq 0$, an interrupt is produced. These two instructions can increase the execution efficiency of the P and V operations.

In addition it is desirable that the processing of the branch subroutine be convenient and flexible. There are many ways of implementing the branch subroutine, but in general they use specialized instructions. In the peripheral processor, with ordinary conditional branches and unconditional branches the address of the next instruction can be saved as part of the operation. If

the k-th instruction in the subroutine is

branch	b'	b	d
--------	----	---	---

, the result of its execution is $k + 1 \rightarrow b'$, and the branch is $(b) + d$. Obviously, if it is not necessary to save $k + 1$, it suffices to write a zero in b' . But because there are only a few index units in hardware, this becomes inconvenient when the subroutine has many levels of nesting. In order to solve the problem of nesting in the next subroutine, two instructions, "branch" and "return," are provided. The idea is to arbitrarily open an arbitrary area in memory as a stack and use an index unit as the stack pointer. Then,

the function of the "branch" instruction is: $\begin{cases} k + 1 \rightarrow (b'), & (b') + 2 \rightarrow b' \\ \text{branch to subroutine entrance} \end{cases}$

the function of the "return" instruction is: $\begin{cases} (b) - 2 \rightarrow b \\ ((b)) \rightarrow \text{program counter} \end{cases}$

These two instructions must be used as a pair. The advantage of this requirement is that they are easy to use and highly flexible, any area in memory may be used, and the stack size is flexible. This is easy to implement and no additional hardware is needed.

VIII. Address Protection

The peripheral processor uses the page protection method. Unified addressing is used for the core storage, semiconductor fixed storage, and miscellaneous registers; the entire address space is 128K words. The entire address space is now divided into 128 pages, each with 1,024 elements. The software manages them in accordance with system requirements and user requests for storage space allocation. The following are recorded for each page: the state (the program has three states: core, supervisor, and user) whose programs are being used, and whether just read or both read and write are enabled. A page table is implemented in semiconductor memory. The page table has 128 elements, each of 14 bits, including 2 parity bits.

When the logical addresses for instruction fetch or data load and store must be looked up in the table, the high-order seven bits (the logical page number) are used in the address to be accessed in the page store. The relevant element in the page store is accessed and a determination is made whether it has address protection. If access is permitted, the real page number stored in that page element and the low-order 11 bits of the page number are combined into a real address which is used to access the internal storage.

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INFORMATION EXCHANGE BETWEEN 757'S VECTOR COMPUTER AND PERIPHERAL PROCESSOR AND DISK-TAPE CHANNELS

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 2, 1984 pp 49-53

[Article by Liu Pixuan [0491 0012 4821], Institute of Computing Technology, Chinese Academy of Sciences]

[Text] I. Overview

In the 757 large high-speed computer system, a two-machine architecture in which functions are divided between a vector processor and a peripheral processor is used in order to make full use of the high-speed vector machine's efficiency. The vector machine runs primarily applications programs and performs high-speed scientific calculations; the peripheral processor executes primarily system programs, runs the operating system and the compiler system, and controls the various peripheral devices.

During system operation, the vector processor and peripheral processor notify each other of situations, and interrogate and respond to each other; the vector processor must go through the peripheral processor to use the peripheral devices; batch information exchange between the vector processor and peripheral processor and man-machine communications must also be effected via the peripheral processor. The vector processor, peripheral processor, and peripheral devices make up the complete 757 computer system (see Figure 1).

In order to decrease the demands on the peripheral processor and increase information exchange speed, two high-speed direct digital channels are provided between the vector processor and the disk units, tape units, electrostatic printer, and graphic display unit so that disk and tape resources can be shared by the vector processor and the peripheral processor.

II. Information Exchange Between the Vector Machine and Peripheral Processor

There are three different connection types between the vector machine and the peripheral processor.

1. Direct Notification Mode: When an emergency situation develops in either of the two machines, the machine emits an interrupt message which is directly communicated at once to the other machine. After the other machine

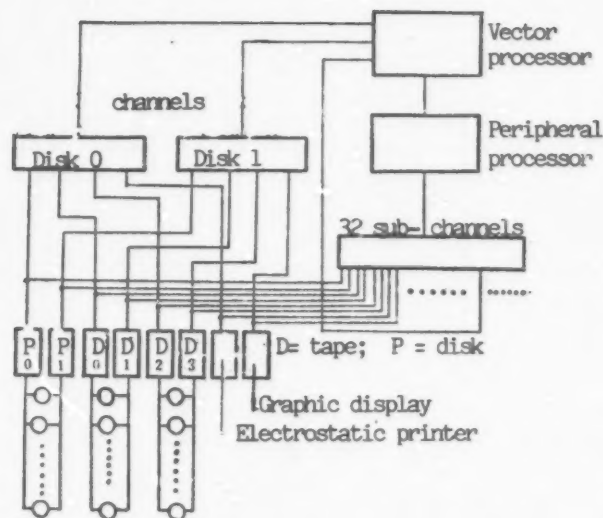


Figure 1. Block Diagram of 757 Computer System

has responded to the interrupt, it branches to the proper interrupt processing program. For example, when there is a power loss, machine stoppage or hardware fault in the peripheral processor, the peripheral processor emits a peripheral processor emergency signal to the vector processor, which is communicated to the latter directly, so that the vector processor ceases exchanging information with the peripheral processor. When a hardware fault occurs in any unit of the vector processor, it immediately emits a vector processor fatal hardware fault interrupt to the peripheral processor, which branches to the relevant routine.

2. Communication Mode: Specialized communications interface hardware is provided in both machines. The two machines use their respective communication instructions to converse and to interrogate each other and to determine each other's requirements. The vector machine's memory control unit is provided with a vector processor-peripheral processor communication register, J_{XW} , 64 bits long. The vector processor's operation control unit is provided with a peripheral processor-vector processor communication register, J_{WX} , 64 bits long. The communication control signals transmitted between the two machines include the relevant communication interrupt request signals and the corresponding response signals. Both machines use their respective communication instructions to initiate communications interfacing.

The vector processor's system instructions include two communication instructions used exclusively by the core state: an instruction by which the peripheral processor sends information to the vector processor, $WCJ \rightarrow XLJ$, and an instruction by which the vector processor sends information to the peripheral processor, $XLJ \rightarrow WCJ$. When the instruction $WCJ \rightarrow XLJ$ is executed, after the contents of the outgoing communication register J_{WX} are received by the vector processor, it sends a response signal to the peripheral

processor and clears the " J_{WX} busy" flip-flop to zero. When the instruction $XLJ \rightarrow WCJ$ is executed, after the vector processor sends information to the outgoing communications register J_{WX} , its busy flag is set at 1; after the information reaches J_{WX} , it sends a communications interrupt request signal to the peripheral processor.

The peripheral processor's instruction set is similarly provided with two special core state communication instructions: the incoming communication instruction #TR and the outgoing communication instruction #TC. When #TR is being executed, after the peripheral processor has received the contents of the outgoing communications register J_{XW} , it sends a response signal to the vector processor and clears the " J_{XW} busy" flip-flop to 0. In executing #TC, the peripheral processor sends the information to the communications interface J_{WX} and sets its busy flag at 1; after the signal is sent to J_{WX} , it sends a communications interrupt request to the vector processor.

The two processors thus use communications instructions and the interrupt mode for communication and response.

3. The Batch Transmission Mode: The vector machine and peripheral processor each have a main storage; the main storages are not shared. In order to allow rapid batch information exchange between the two main storages, a direct data channel is provided between the two machines. For the peripheral processor, this direct data channel is 1 of its 32 subchannels (see Figure 1).

The vector machine's memory control unit is provided with seven main storage access channels: correspondingly, it has the disk channel 0 request P_0Q , the disk channel 1 request P_1Q , the instruction control unit instruction fetch channel request ZQ , the look-behind storage data wait station channel request HQ , the memory control unit instruction stack buffer register channel request ZDQ , the peripheral processor 0 channel request W_0Q , and the peripheral processor 1 (expandable) channel request W_1Q (see Figure 2). These seven channels are time-share queued into the instruction control unit pipeline stations in accordance with a priority system. Because the peripheral processor is slower than both the vector processor and the disk units, and signal exchange is not timed, so that the peripheral processor has the lowest priority level in the time-shared queue.

The specialized hardware interfaces provided in the vector processor memory control unit for the direct data channel to the peripheral processor include a data buffer station and a control command word register. The data buffer station consists of 16 64-bit shift buffer registers WH (Figure 3). Its inputs can come from the peripheral controller code line or from the memory control unit's internal storage data readout buffer J_{ds} . Its output can be sent via long lines to the peripheral controller or can be sent to the memory control unit's internal storage data write register J_{xs} . The data codes in WH can be transferred in or out by the peripheral device controller's synchronization pulses, or by the memory control unit's condition pulses. The control word register includes the request address register WQD , the local exchange number registers WL , and the read-write flag WXM .

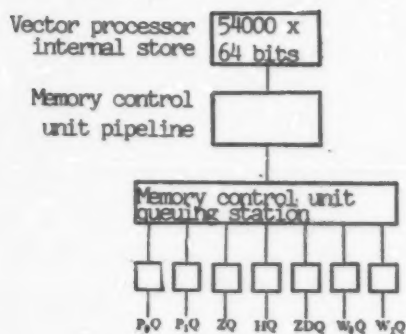


Figure 2. Internal Access Channels of the Vector Processor Memory Control Unit

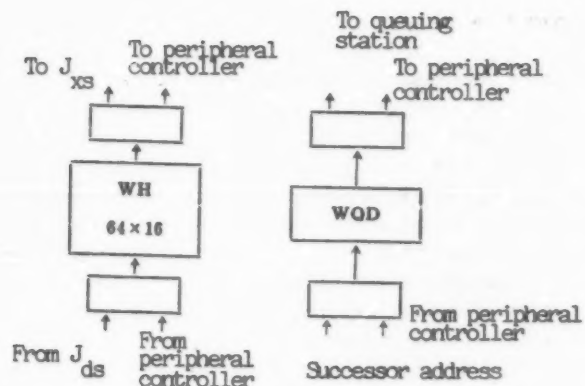


Figure 3. Vector Processor's High-Speed Channel Interfaces With Peripheral Processor

Reading from the vector machine's internal storage and transmitting the result to the peripheral processor is performed as follows. After the peripheral controller has sent the starting address of the data exchange with the peripheral processor, the exchange length, and the read-write flag, it sends the preliminary request signal Z^1C_{WYQ} to the memory control unit. It then waits until the vector processor memory control unit has completed the exchange and has sent the response signal C_{WHD} , and uses this response signal to control the sending of the next request signal. After the memory control unit receives the preliminary request signal from the peripheral controller, it loads this signal into the peripheral processor request flip-flop C_{WQ} , synchronized by peripheral processor pulses. It then waits while the memory control unit performs time-shared queuing. After the current request is put into the queue, the memory control unit produces a load instruction $NC \rightarrow W$ which enters the various stations of the memory control unit's pipeline and successively reads out a quantity WL of data words from internal storage and loads them into WH . After this operation is completed, the memory control unit sends an "exchange completed" response signal to the peripheral controller. Then, again in accordance with the peripheral controller synchronization pulses, it successively transfers the data in WH to the peripheral controller's receiving register. After WL components have been exchanged, the memory control unit forms the successor address and loads it into WQD . If the request which the peripheral controller sends on the next occasion does not include a new request address, the successor address begins to be exchanged from WQD until one data area has been completely exchanged.

Writing into the vector processor's internal storage by the peripheral processor: After the peripheral controller transfers the request control word to the memory control unit, the exchange codes of the WL numbers which are to be written into the vector processor's internal storage are transferred into WH in accordance with the controller synchronization pulses. Then the peripheral controller sends a preliminary request signal Z^1C_{WYQ} to the memory control unit. After the memory control unit receives this signal

from the peripheral controller, in synchrony with the memory control unit's pulses, it stores the preliminary request signal in the peripheral processor's channel request flip-flop CWQ and places it in a time-shared queue. Once the current request has been placed in the queue, the memory control unit emits the stored instruction $W \rightarrow NC$ which enters the stations of the memory control unit's pipeline; the $W \rightarrow NC$ instruction successively writes a number WL of data words which are in WH into WL memory cells in main storage, beginning with WQD. After the writing is completed, the memory control unit sends an "exchange completed" response signal C_{WHD} to the peripheral controller. The peripheral controller uses the response sent by the memory control unit to control preparations for the next exchange request. Similarly, provided that the peripheral controller is continuously sending request signals, the successor address which the memory control unit saves in WQD can carry out exchange of a data area.

III. Information Exchange Between the Vector Processor and the Disk-Tape Channels

In order to increase the data transmission rate and decrease demands on the peripheral processor, the vector processor and peripheral processor share disk and tape resources. The system also has two high-speed direct data channels between the vector processor and the magnetic disk units, magnetic tape units, electrostatic printer, and graphic display unit. The eight subchannels Disk 0, Tape 0, Tape 2, Electrostatic Printer, Disk 1, Tape 1, Tape 3, and Graphic Display are divided into two groups; the first four are combined into one path which forms a direct channel for information exchange with the vector processor's main memory and is called the Disk 0 channel for brevity; the latter four subchannels are also formed into a path, comprising the second direct data channel, which is called Disk 1 for brevity. To meet the requirement for direct access to the vector processor, and in particular to adapt to the speed of the disk unit, a special controller is provided; this is generally called the disk-tape channel controller or, for brevity, the disk controller.

Because the disk-tape channels are clocked, they have the highest priority level within the vector processor memory control unit among the seven internal storage access request channels. Similarly, the disk-tape channel operates under the control of the peripheral processor and the vector processor is passive. If the operating frequency of the disk unit is 8 MHz, 215 ns is required to read out each bit of information from the disk. Since one word is 64 bits, 16 μ s is required to read out a word. Thus, it takes 256 μ s to exchange 16 words of data. The maximum time elapsing from the vector processor memory control unit's reception of the request signal sent out by the disk channel to the end of transmission of 16 words of data is 73 μ s (with a vector processor operating frequency of 10 MHz). Under these circumstances, to accelerate the transmission rate, two data buffer shift registers have been provided for each disk channel at the vector processor's memory control unit interface; each has a capacity of 64 bits x 16 words, and they are called Disk Buffer 0 and Disk Buffer 1 (PH_0 and PH_1), as shown in Figure 4. The two disk buffers can receive data read out of internal storage or data from the disk controller; both of them can also send data

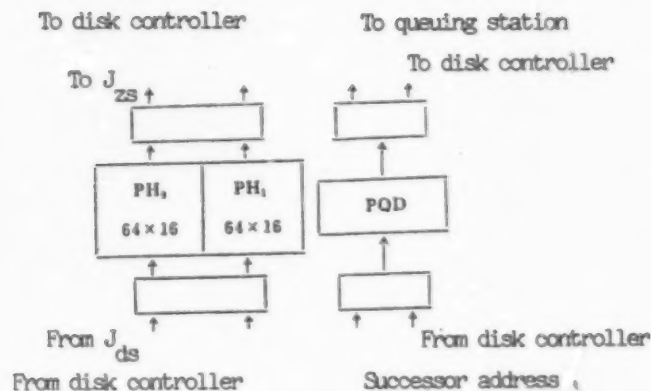


Figure 4. High-Speed Channel Interface Between Vector Processor Memory Control Unit and High-Speed Disk-Tape Channel

to internal storage or the disk controller. In addition they are capable of parallel alternate operation. For example, when reading from the vector processor's internal storage and writing on the disk, while the 16 words in one disk buffer are being written onto the disk, the other disk buffer can be receiving the next batch of 16 words from internal storage in preparation for writing onto the disk. When reading from the disk and writing into the vector processor's internal storage, while the 16 words of data in one disk buffer are being written into internal storage, the other disk buffer can be receiving the next batch of 16 words from the disk in preparation for writing into internal storage.

As in the case of the direct data channel to the peripheral processor, the memory control unit has been provided with a request control word register for the disk channels, which includes the disk request address register PQD, the exchange length register PL, and the read-write flag PXM.

Reading main storage and writing onto disk, NC → P: After the disk controller sends the request control information, i.e., the starting address, exchange number, and read-write flag, for exchange with the vector processor internal memory, it sends the preliminary request signal $Z^{11}C_{PQ}$ to the memory control unit. After the memory control unit receives the preliminary request signal, the signal is sent to the disk channel request flip-flop C_{PQ} in synchrony with the memory control unit's pulses, where it is placed in the memory control unit access channels queue. After it is placed in the queue, the memory control unit produces a load instruction NC → P which enters the various stations of the memory control unit's pipeline and reads out 16 bits of data from the internal storage (or a number PL of words) and sends them to the disk buffer. Then the memory control unit sends out another request and reads from internal storage the adjoining 16 words of data, which are sent to the other disk buffer. When the two disk buffers are full, the memory control unit sends the response signal C_{PHD} to the memory control unit. When

the disk controller receives the response signal, its synchronization pulses are used to transfer the data in one disk buffer to the disk controller's receiving registers; after all of the data is transferred out of one disk buffer, another request to read from internal storage onto the disk is sent to the memory control unit. After the memory control unit receives the request, it reads out 16 words of data from internal storage and forwards them to the disk buffer that has just been emptied, as outlined above. At the same time, the disk controller is transferring the 16 words from the other disk buffer to the disk controller to be written onto the disk. In this parallel alternate operation by the two disk buffers, emission of the successor address is controlled by the memory controller until the data in a data area within internal storage have been entirely read out onto the disk.

Reading from disk into the vector processor internal memory, $P \rightarrow NC$: After the disk controller sends a request control word signal to the memory control unit, the disk controller's synchronizing pulses are used to shift the 16 words of data (or PL words of data) read out from the disk into the disk buffer, after which a preliminary request signal $Z^{11}C_{PY0}$ is sent to the memory control unit. After the memory control unit receives the request signal, the memory control unit's pulses synchronize the loading of the request signal into the disk channel request flip-flop C_{PQ} where it is placed in the memory control unit's internal storage access channel queue. After it is placed in the queue, the memory control unit it produces a write data instruction $P \rightarrow NC$, which enters the stations of the memory control unit's pipeline and reads the 16 words of data in the disk control unit successively into memory; when this is completed, it sends a response signal C_{PHD} to the disk controller. When the memory control unit is writing the 16 words from one disk buffer into internal storage, it is also transferring the data read out from the disk into the other disk buffer. When the disk controller receives the response signal from the memory control unit and the data in the other disk buffer are ready, it sends a write into main storage request to the memory control unit. After this request is sent out, one disk buffer writes the data into main memory, while the other disk buffer, which has already been emptied, under the control of the disk controller, prepares the next batch of data for writing into main memory. This parallel alternate operation of the two disk buffers is well suited for increasing disk speed and effectively increases data transmission rates.

In order to control the parallel in-and-out alternations of the two disk buffers, the memory control unit is provided with two corresponding control flip-flops which are called the disk buffer in flip-flop (C_{PHR}) and the disk buffer out flip-flop (C_{PHC}) (see Figure 5). They are both D-type flip-flops. $C_{PHR} = 1$ puts PH_1 into the entry state; $C_{PHR} = 0$ puts PH_0 into the entry state. $C_{PHC} = 1$ puts PH_1 into the output stage; $C_{PHC} = 0$ puts PH_0 into the output stage. When the system is started up (and the entire machine is set at 0; i.e., QJZO), $C_{PHR} = 0$ and $P_{PHC} = 1$. Thereafter, every time an enter pulse arrives, the two flip-flops change state and control the input and output gates of the two disk buffers so that they are alternatively in the input and output states.

When the disk buffer is writing onto the disk, the control voltages emitted by the two disk buffers are:

$$\begin{aligned} \text{PH}_0\text{SP} &= \overline{\text{PDHS}} \wedge \overline{\text{C}_{\text{PHC}}} \\ \text{PH}_1\text{SP} &= \overline{\text{PDHS}} \wedge \text{C}_{\text{PHC}} \end{aligned}$$

When the disk buffers are writing into internal storage, the control voltages emitted by the two disk buffers are:

$$\begin{aligned} \text{PH}_0\text{XS} &= \overline{\text{PDHS}} \wedge \overline{\text{C}_{\text{PHC}}} \\ \text{PH}_1\text{XS} &= \overline{\text{PDHS}} \wedge \text{C}_{\text{PHC}} \end{aligned}$$

When the disk is writing into the disk buffers, the control signals sent to the two disk buffers are:

$$\begin{aligned} \text{PXP}_0 &= \overline{\text{PXM}} \wedge \overline{\text{C}_{\text{PHR}}} \\ \text{PXP}_1 &= \overline{\text{PXM}} \wedge \text{C}_{\text{PHR}} \end{aligned}$$

When internal memory is writing into the disk buffers, the control voltages sent into the two disk buffers are:

$$\begin{aligned} \text{NXPH}_0 &= (\text{NCSP})_6 \wedge \overline{\text{C}_{\text{PHR}}} \\ \text{NXPH}_1 &= (\text{NCSP})_6 \wedge \text{C}_{\text{PHR}} \end{aligned}$$

Here PDHS is the address recovery voltage sent by the disk controller. It is used to control the selection of whether the information sent via the code line to the disk controller is the main machine internal storage request (PQD) or the code to be exchanged (PH₀ or PH₁). (NCSP)₆ indicates that the sixth station in the memory control unit's pipeline holds an instruction for internal storage to transmit to disk; at this time the data which is read from internal memory into the memory control unit's data read register J_{DS} should be forwarded to the disk buffer.

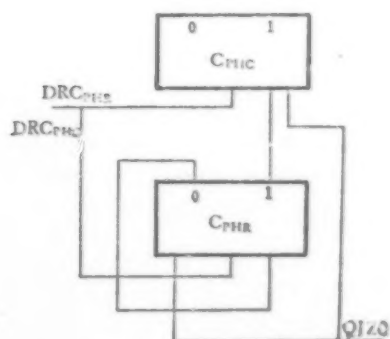


Figure 5. Control of Two Disk Buffered Input/Output Parallel Alternation

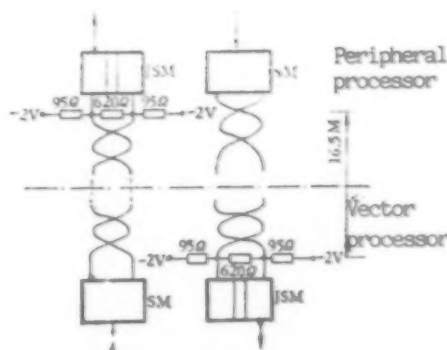


Figure 6. Long-line Transmission of the Vector Machine and the Peripheral Processor

IV. Implementation of Information Exchange by Long-Line Transmission

All of the logic circuits in the 757 vector processor use Chinese-made high-speed ECL [emitter-coupled logic], medium- and small-scale integration circuitry, but the peripheral processor's logical circuitry uses TTL [transistor-transistor logic] integrated circuits. Therefore, the transmission of data and control signals between the vector processor and peripheral processor must undergo E-T or T-E conversion. In the current system, the vector processor is installed downstairs, and the peripheral processor and peripheral devices upstairs, with information transmission lines up to 16.5 meters long. In order to assure reliable transmission, the long-line transmission makes use of twisted-pair duplex transmission of ECL signals (Figure 6). The sending end uses a dual gate SM as a duplex send gate. The receiving end uses an ECL receiving gate JSM to receive the dual-gate ECL signals from the long lines. All E-T and T-E voltage level conversion is carried out by the peripheral processor. In order to match the resistance of the entire ECL system, three-resistor matching is used in the receiving gates at the end of the long lines.

In order to save layout space these three resistors are also realized as integrated circuit resistor networks. In addition, long-line twisted pair transmission lines of suitable characteristics were also specially designed. Theoretical analysis, computer calculations and experience have shown that this type of transmission and matching method gives a small reflection factor, little signal crosstalk, little waveform distortion, and low voltage losses. Prolonged reliable operation of the entire machine has also confirmed that the design of the transmission system is entirely reliable.

The method by which data and control information are transmitted between the vector processor and the disk-tape channel is entirely analagous to the method of transmission between the vector processor and the peripheral processor described above and will not be discussed further.

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AUTOMATED HARDWARE FAULT PROCESSING ROUTINES OF 757 COMPUTER

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 2, 1984 pp 54-57

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[Text] I. Introduction

Malfunctions in computer operation may cause major losses. Accordingly, when designing a computer system, it is important to give it protective redundancy and to enable the system to go on operating correctly or at least not to become paralyzed when hardware or software faults occur. Fault tolerance was taken as an objective in the system design process, and hardware and software were integrated in order to implement automatic handling of hardware faults, so that when malfunctions occurred the opportunity to continue running the current job was maximized, or if this was impossible, the likelihood of system paralysis was minimized. As a result of this approach, most nonpermanent faults can be overcome and will not affect normal job processing. In the case of permanent faults which cannot be dealt with, the malfunction can be located in timely fashion, thus greatly decreasing machine maintenance time and extending the time between failures, which saves time and manpower and increases machine availability. These factors are particularly important for large high-speed computers. In general,

$$A = \frac{MTBF}{MTBF + MTTR}$$

where A is the availability (usability), percent; MTBF is the mean time between failures; and MTTR is the mean time to repair.

The smaller the number of malfunctions and the greater the probability of their recomputability, and in addition the shorter the repair time, the greater the efficiency of the machine will be.

In addition, we made some fundamental alterations in fault management. For many years the maintenance personnel were expected to maintain a log, keep malfunction statistics, analyze faults, and identify and repair them. Not only was this laborious, but the correctness and detail of the records varied from individual to individual. In order to overcome these

deficiencies in the 757 described here, in addition to implementing automatic fault processing we also instituted automatic detailed logging of faults. Such information as the time of occurrence and location of the fault, its nature, the method of dealing with it and the results achieved are all recorded in detail. In this way, the maintenance personnel can make regular statistical analyses and can receive information on faults at various stages simply by using the keyboard or typewriter. It is also possible to keep statistics automatically, to analyze the characteristics and causes of faults that occur, and to increase the quality of machine maintenance and management; these factors also helped improve design.

II. Fundamentals of Hardware Interrupt Processing in the 757 Mainframe

In the 757 the peripheral processor (WCJ) diagnoses the mainframe (XLJ). The mainframe's assignments and states are recovered and subsequently cleared by the "communication out" (TC) instruction and the "communication in" (TR) instruction in the peripheral processor. A small fan-in-fan-out unit (SRC) is installed between the peripheral processor and mainframe. The TC instruction gives the mainframe and the fan-in-fan-out unit (SRC) a series of instructions and data which are analyzed by the SRC: if they are instructions, then a series of control voltages is produced, which control the mainframe's fan-in or the information saved from control gates, while if they are data, then they are fanned into the mainframe's corresponding registers or flip-flops. The TR instruction causes the states recovered from the mainframe to be stored in the peripheral processor's internal memory.

Parity check points are provided at certain locations in the various units of the mainframe, and Hamming code test points at some key locations. Clear, fan-in and voltage save are provided at key flip-flops and registers in order to allow assignment and sensitization of certain paths. When a hardware fault is discovered, the appropriate control unit's hardware fault interrupt message is sent out, the clock in the control unit where the fault has occurred immediately stops, and all pulses are suspended throughout the machine. An interface is provided between the malfunctioning control unit and the other control units so that information coming from the other control units is not lost. This makes it possible to save the current state. In addition, certain save stations are provided so that after the stoppage occurs it is possible to reconstruct useful states. After a hardware fault is discovered in the vector processor, a "mainframe fatal fault" interrupt is sent to the vector processor.

A diagnostic unit switch is provided on the mainframe's maintenance and control panel, together with retry switches for the various control units. When it is not desired to diagnose operation, the diagnosis unit can be cut out and hardware faults may be processed without diagnosis. If for various reasons to double calculate is impossible in one of the control units, the retry switch for that unit can be used to cut out double calculation, while double calculation can still be carried out as usual in the other control units.

III. Control Connections Between the Operating System and the Diagnostic Interrupt Programs

When the peripheral processor WCJ receives a mainframe fatal fault interrupt, the operating system informs the diagnostic interrupt program of the status of the peripheral processor's internal storage (Figure 1) and transfers control to the main diagnostic interrupt control program.

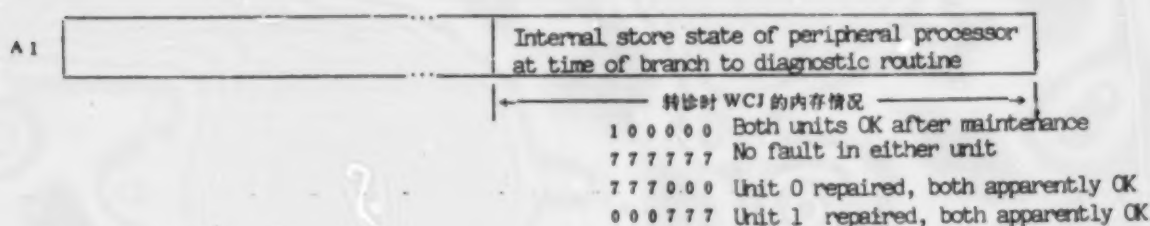


Figure 1.

The work of the main diagnostic interrupt control program starts with saving of the states of the peripheral processor and mainframe in order to assure their correctness and guarantee that the job currently being run can be resumed; if this is impossible, it tries to prevent system paralysis. Human intervention is minimized, and an effort is made to do everything automatically, which increases machine efficiency.

The control switching between diagnosis and the operating system is diagrammed in Figure 2.

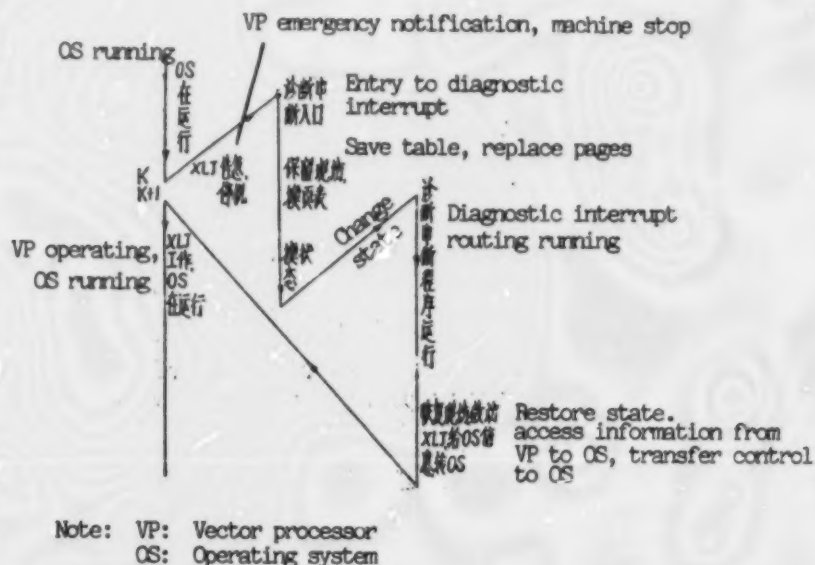


Figure 2.

The operating system switches from the core state to the diagnostic interrupt program. After branching to this program, it saves the old status word and the old interrupt entry as well as the contents of the communications interrupt flag bit C_{DXW} and the communications register (WX). It changes to a new interrupt entry point, changes the page table, and changes to the new status word, after which the diagnostic interrupt program operates in the diagnostic mode, and the peripheral processor begins to carry out the various types of TC instruction processing in which each time it carries out a TC instruction it initiates operation of the SRC [fan-in-fan-out unit] and sends the contents of WH [communication register] to the SRC unit. Under control of the SRC unit, it performs assignment, recovery and clearing in the mainframe. On performance of the diagnostic interrupt, the diagnostic interrupt lamp lights.

IV. Fault Processing

After the diagnostic interrupt program has saved the current state, by analyzing the mainframe interrupt word and the fault detection word of the relevant control unit it can find the reason for mainframe stoppages, and accordingly it has a variety of methods of handling them. When the error state can be reconstructed and accordingly is recomputable, it branches to the retry program of the control unit in which the fault occurred, and after the retry is performed it returns to the diagnostic interrupt program and starts the mainframe; at this point it is still under the control of the diagnostic interrupt program. After a successful double-calculation, the mainframe is started and waits for logging to be performed; after the machine stoppage condition is cleared the mainframe status is restored, and if the entire machine is fault-free the mainframe is started and control is transferred to the operating system.

If the double-calculation is not successful, another is attempted. During each double-calculation, in addition to execution of the program itself there is also a delay of 200 msec; it is assumed that after 7 double-calculations an intermittent fault should have disappeared. After a successful double-calculation, control is transferred to the operating system. If another malfunction occurs, the transfer to the operating system is made after further processing. If the malfunction that occurs is nondouble-calculable, then alternate programming is undertaken (switch to another job). If the same fault appears repeatedly, a branch is made to the diagnostic program of the unit in which the fault occurs in order to locate it, and the number of the card that is identified, the number of the control unit involved, and the time at which the malfunction occurred are shown on the display; after the maintenance technician has replaced the card, he uses the keyboard to type an order and to report the number of the card that has been replaced (the malfunction has also been automatically logged) and the relevant diagnostic program verifies the replacement. Once the fault is eliminated, the system is returned to alternate processing. When the mainframe is started, it is in the general stop [guang ting [1639 0255]] state, waiting for control signals to be sent from the operating system in the peripheral processor. The return is made to alternate processing on the basis of information from the diagnostic routine.

V. Exit From the Diagnostic Interrupt Routine

After the diagnostic interrupt program has carried out double calculations or diagnosis, it sends information to the operating system informing it of the status of the mainframe's internal storage, the status of exchange with peripherals, the retry status, the state of the mainframe at the time of the stoppage and the like, so that the operating system can take the proper steps; this information is sent via accumulator A (see Figure 3).

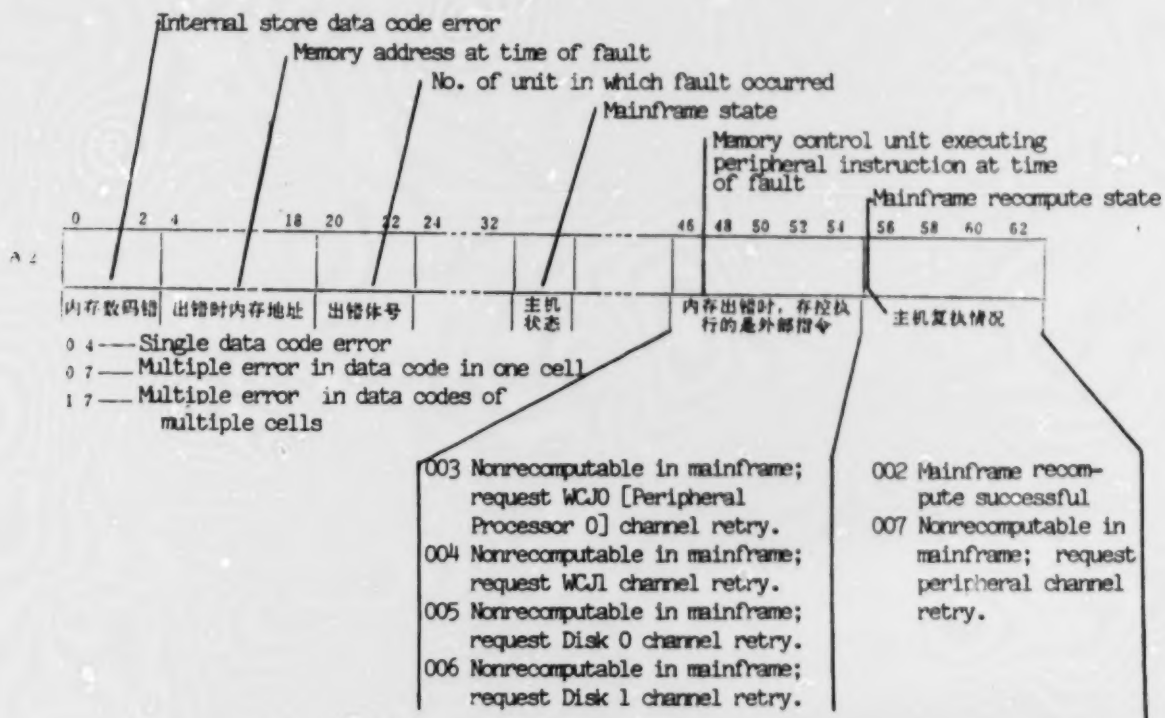


Figure 3. Information Sent by the Diagnostic Interrupt Program to the Operating System

Because the WCJC (peripheral processor) and the XLJ (mainframe) operate asynchronously with respect to each other, restoration of state and starting of the mainframe must be processed in the proper sequence; otherwise errors will result and the system will not operate normally. In addition, the number of jumps, between the operating system and the diagnostic interrupt program must be minimized. After branching to the diagnostic interrupt, if possible when processing is completed the mainframe should be turned over to the operating system in fault-free condition; this makes for correctness and can increase efficiency.

[Following two sentences garbled in original.] Communications interface register WX (in the peripheral processor) and the saving and restoration of communications interrupts. In the nondiagnosis state, register WX functions as a communications interface register between the peripheral processor and the mainframe, and during communications when the mainframe produces a communications interrupt (bit 29 in interrupt word T 1[29]). When the mainframe stops, it may be at various stages in the processing of a communications interrupt or may not yet have begun processing. In the diagnostic state, WX sends information from the peripheral processor to the SRC [fan-in-fan-out unit and the mainframe, and accordingly the problem of releasing and recovering communications interface WH arises; continuity in communications interrupt processing must be maintained in order for the system to operate correctly.

VI. Emergency Notification by Operator

If a diagnostic program must be executed during system operation, a fault record is displayed (or printed out); when a fault record is displayed or one unit is substituted for another, it is necessary to enter the diagnostic state. The "emergency notification by operator" mode can be used to run the diagnostic interrupt program, after which a keyboard command is used to enter a request.

A notification of emergency can be made by pressing the "emergency notification" button on the mainframe maintenance panel or the peripheral processor monitoring and control panel. When there is no malfunction in the mainframe, after the keyboard command is executed, it can continue operation without disrupting execution of the job, provided that the state of the mainframe has not been disturbed.

VII. Fault Logging and Display

Each time a malfunction develops in the mainframe or it stops because of an emergency notification by the operator, the time of the malfunction and its detailed location must be recorded.

The memory contains two pages for diagnosis; 256 units are allocated for fault logging, and if these 256 units are filled the information is stored on disk as a record. The date of the first fault is used as the name of the record, and when necessary it can be read out and printed or displayed. In addition, fault records showing the details of card replacement can be printed out.

The individual items in a fault record are shown in Figure 4.

The principle on which the design of this diagram is based is that of dealing with the machine stoppages caused by hardware faults in the mainframe as clearly as possible. The time of emergency notification by the operator is also logged. In addition, the number of faults in a given control unit in the mainframe can be displayed at signal light T₃ on the control panel, making it easy to determine the fault frequency. These features give a clear indication of fault circumstances in the mainframe, increase the quality of maintenance, and avoid time-consuming work for the maintenance personnel.

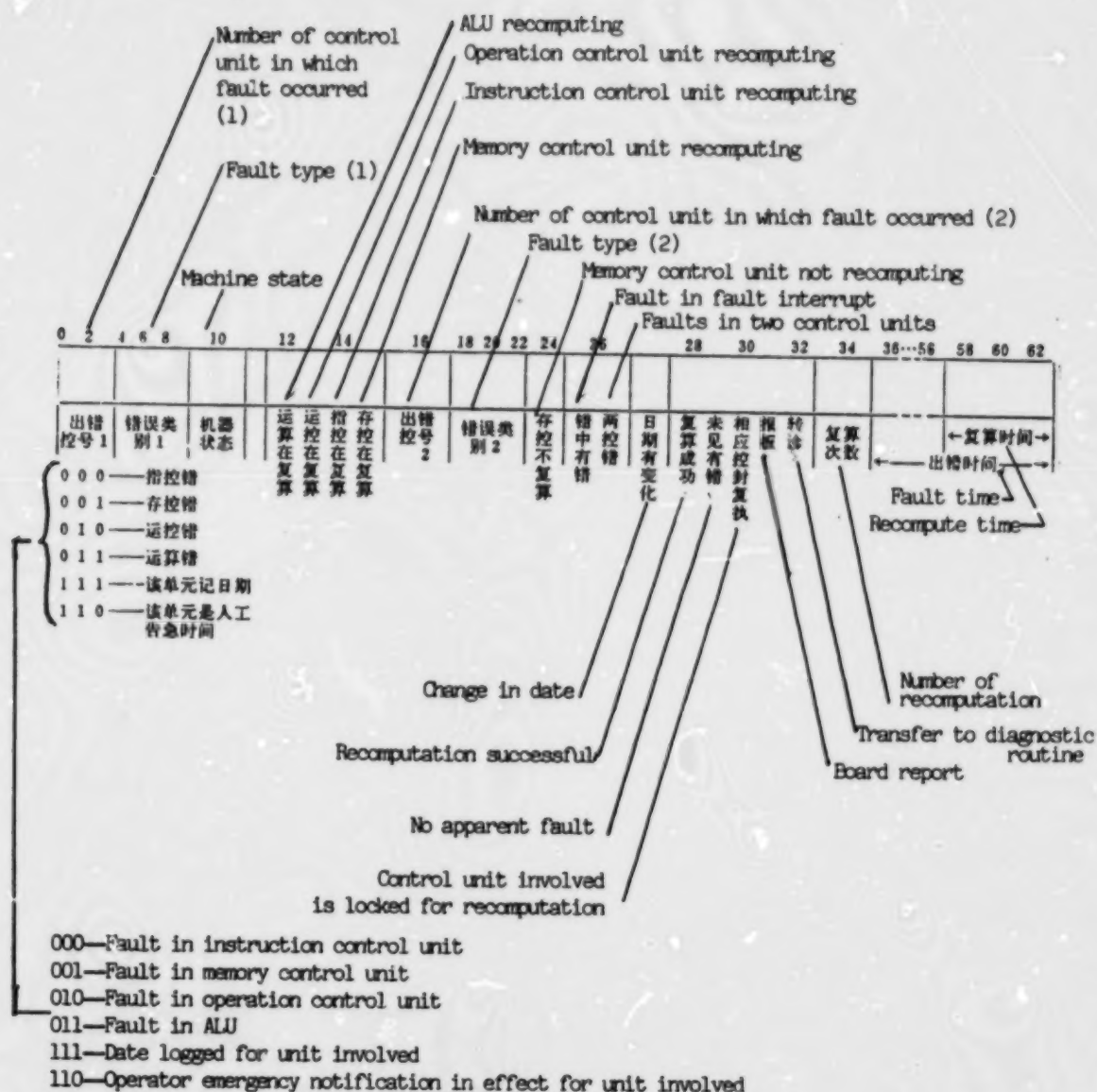


Figure 4. Fault Logging Record

VIII. Conclusions

Fault-tolerant design with software-hardware integration is implemented in this machine. We have implemented rather good automatic processing of hardware faults, with double-calculation or diagnosis and fault location, and have provided automatic fault management and logging, which has decreased operator intervention and improved efficiency. This is extremely helpful in increasing machine reliability, maintainability, and efficiency. Other

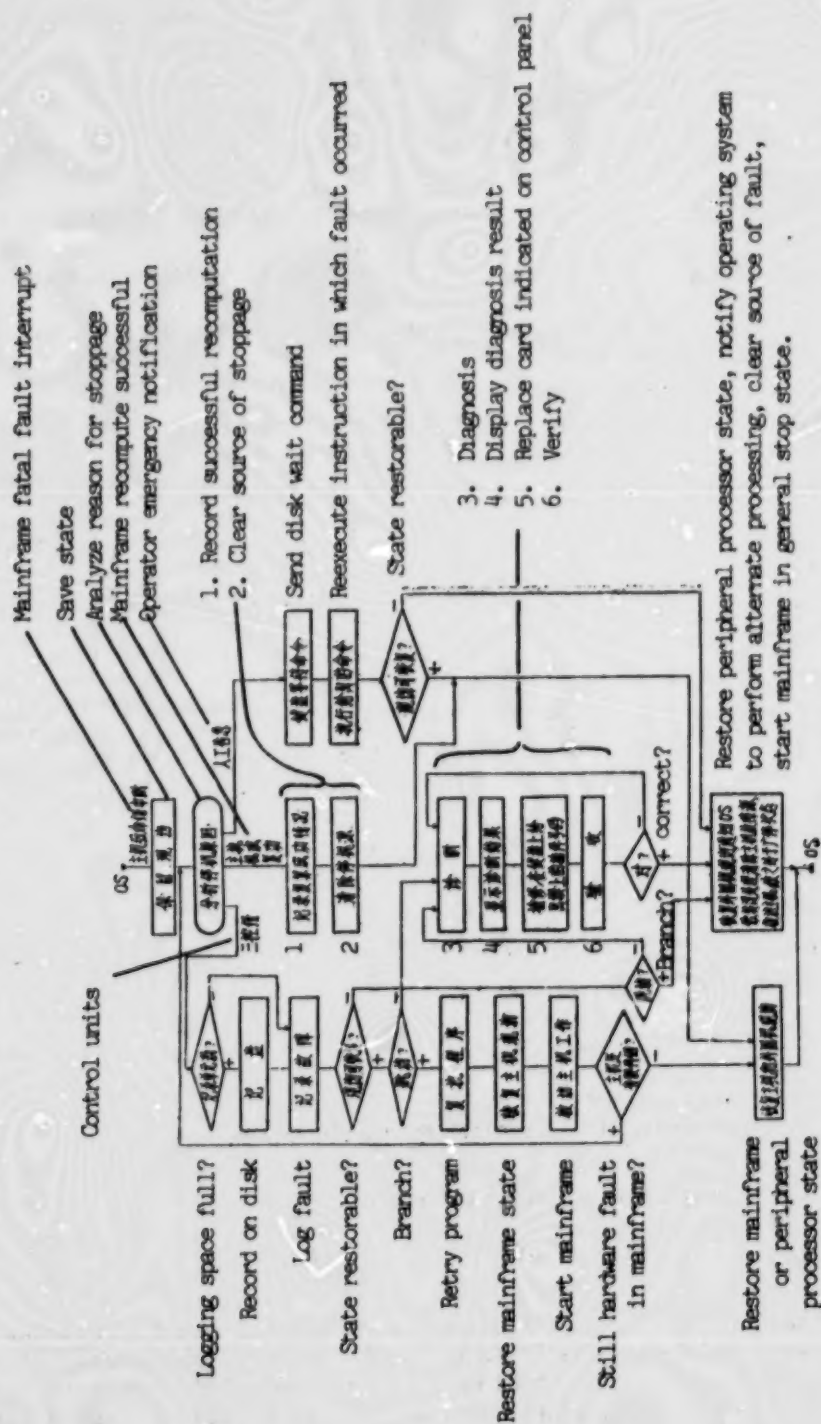


Figure 5.

effects are sure to manifest themselves during future machine operation. This obviously constitutes gratifying progress in fault-tolerant design, but it is still far below the level of the fault tolerant design of some machines in the world arena, and there are many points that still merit discussion and improvement.

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DESIGN OF MULTIBIT COMPARATOR FOR 757 COMPUTER

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[Text] Abstract. Comparators are extremely widely used in digital computer logic circuitry and digital devices. Multi-bit comparators can be made by cascading 2-bit and 1-bit comparator elements, but they are rather slow. Another possibility is independent design, but the problem is that there are too many variables and it is rather toilsome to simplify the functions involved. This article describes a 19-bit comparator designed for the 757 large-scale computer's instruction control unit, as well as the design method that was used.

I. Design Requirements

The instruction control unit of the 757 computer contains three counters to dispatch and fetch instructions; these three counters are the lower boundary address counter X, the instruction address counter JS₂, and the upper boundary address counter S. When an instruction is dispatched from internal storage to the instruction buffer, the upper boundary address counter S points to the internal storage address, and the lower boundary address counter X and the upper boundary address counter S are used to define its location. When an instruction is fetched from the instruction buffer storage to the instruction register, the instruction address counter JS₂ points to the instruction buffer memory address. In many branch instructions, if the branch address Q formed by the computer during operation is equal to or greater than the upper boundary address S (the contents of the upper boundary address are also denoted by S) or if it is smaller than the lower boundary address X (the contents of the lower boundary address are also denoted X), then a fault immediately occurs, and this requires location by the address counters X and S again, after which the instruction is again fetched. These circumstances, i.e., when $Q \geq S$ or $Q < X$, are called "branching out of area." A circuit which has the capability to determine whether $Q \geq S$ or $Q < X$ is a 2-bit comparator. If the comparator itself produces an error, this may cause

chaos in the instruction control unit. Thus, it is obvious that the operation of the comparator is extremely important: it must be not only stable and reliable, but fast.

Computers which we designed previously made very little use of multibit comparators; considerable use was made only of coincidence circuits, which could compare two multibit binary numbers (addresses) and determine whether they were equal. The gate combinations of coincidence circuits are very easy to implement.

There is little information on the design of digital comparators in ordinary books on digital computer principles; it is described in books on the logical design of digital systems. When it is desired to compare two binary numbers, the guiding idea is always bit-by-bit comparison; in some designs the comparison proceeds from the highest to the lowest bit, in other designs from the lowest to the highest. Most multibit comparators use cascaded 2-bit or 1-bit comparators, and accordingly are very slow, so that they do not meet design requirements. The same is true of comparators of modular design. Another possibility is design of independent [i.e. not built up of smaller units] multibit comparators, but the problem is that there are too many variables and it is toilsome to simplify the functions. For example, a 4-bit comparator involves an 8-variable logic problem, and it is difficult to use Karnaugh maps to represent it. Thus, the difficulties involved with a 19-bit comparator can readily be imagined. In addition, multilevel circuitry can be used to implement certain functions, or the factoring method can be used, but the large equations may have many factors, the circuits to implement them have completely different characteristics and it is very difficult to derive the formulas involved.

To summarize the above, we analyzed the branch-out-of-area conditions of the 757 large-scale machine's instruction control unit and used the following approach to implement a multibit comparator based on binary computations.

II. Design of the Multibit Comparator

The basic logic circuits used in the comparator were the ECL-D system of medium- and small-scale integrated circuits produced by the Chinese Academy of Sciences' Plant No 109. They included single gate, quad gate, and quad half-adder circuits.

Let Q , X , and S represent 3 19-bit binary numbers:

$$Q_0Q_1Q_2 \cdots Q_{16}Q_{17}Q_{18}$$

$$X_0X_1X_2 \cdots X_{16}X_{17}X_{18}$$

$$S_0S_1S_2 \cdots S_{16}S_{17}S_{18}$$

It is required to design 2 19-bit comparators for the functions $Q < X$ and $Q \geq S$. This can be realized by means of the following type of implementation.

Comparator Operating Principles

If Q and X are to be compared, we perform the subtraction $Q - X$ and carry out the fixed point complement addition $Q + [-X]_{\text{comp}} = Q + [-X]_{\text{radix-1 complement}} + 1$, ignoring the computation result and taking account only of whether the adder produces a carry; then if $Q < X$ the adder will not produce a carry and the C_j output bit will be at the low voltage level (-1.6 V). Thus the $Q < X$ output will be low and the $Q < X$ output will be high (-0.8 V), indicating that the condition $Q < X$ exists (see figure). Otherwise, the adder will produce a carry and the carry output C_j will be high, so that the $Q < X$ output will be high and the $Q < X$ output will be low, indicating that the condition $Q < X$ does not exist.

If Q and S are to be compared, we perform the subtraction $Q - S$ and perform fixed point complementary addition $Q + [-S]_{\text{comp}} = Q + [-S]_{\text{radix-1 complement}} + 1$, again ignoring the addition result and noting only whether the adder produces a carry. If $Q \geq S$, then the adder produces a carry and the carry output bit C_j will be high; accordingly the $Q \geq S$ output (equivalent to $Q < S$) will be high and the $Q \geq S$ output (equivalent to $Q < S$) will be low, indicating that the condition $Q \geq S$ exists. Otherwise, the adder will not produce a carry, and the carry output bit C_j will be low, so that the $Q \geq S$ output will be low and the $Q \geq S$ output high, this means that the condition $Q \geq S$ does not exist.

In the multibit comparator we used only the relevant parts of the adder carry chain, which saved hardware and increased reliability. The speed of the comparator depends on the type of carry chain. We need to select a carry chain type suited to the comparator characteristics, and in general increasing the speed will require an increased amount of hardware.

We now describe the derivation of the logic design equations: Let $C_j, C_0, C_1, C_2, \dots, C_{15}, C_{16}, C_{17}$ represent the output carry bits resulting from comparison of 2 19-bit binary numbers, and let C_{18} represent the carry bit C_{+1} from the low-order bit ($C_{+1} = -1.6$ V).

If half adders are grouped into a full adder, the half-sum equation is

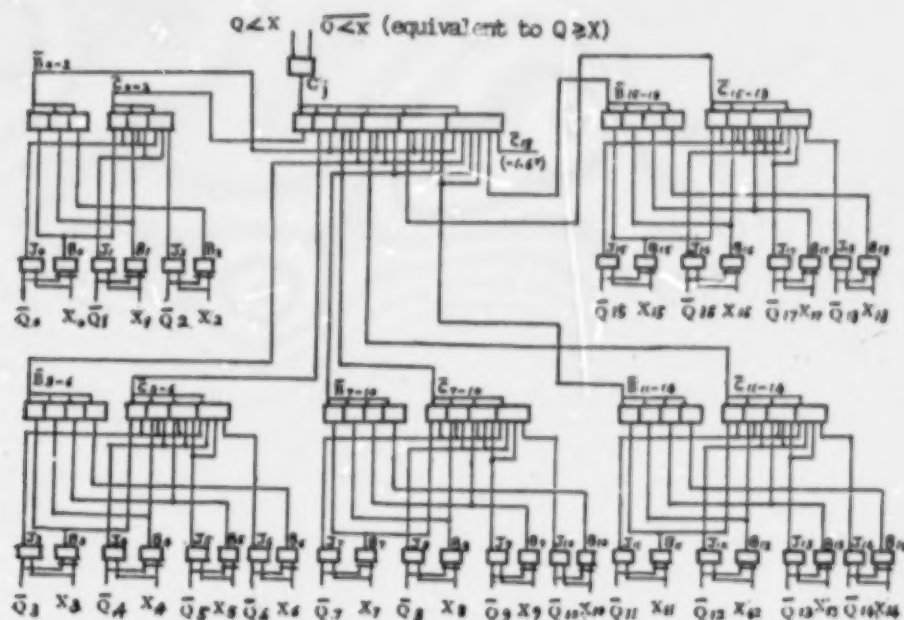
$$B_1 = Q_1 \oplus X_1 \quad (1)$$

the half adder carry equation is

$$J_1 = Q_1 X_1 \quad (2)$$

and the full adder carry equation is

$$C_{1-1} = J_1 + B_1 C_1 \quad (3)$$



Circuitry of Multibit Comparator

From equation (3) and the laws of Boolean algebra we can derive the equations

$$C_{17} = J_{18} + B_{18}C_{18}$$

$$C_{16} = J_{17} + B_{17}C_{17} = J_{17} + B_{17}(J_{18} + B_{18}C_{18}) = J_{17} + B_{17}J_{18} + B_{17}B_{18}C_{18} = (J_{17} + B_{17})(J_{17} + J_{18}) + B_{17}B_{18}C_{18}$$

$$C_{15} = J_{16} + B_{16}C_{16} = J_{16} + B_{16}(J_{17} + B_{17})(J_{17} + J_{18}) + B_{16}B_{17}B_{18}C_{18} = (J_{16} + B_{16})[J_{16} + (J_{17} + B_{17})(J_{17} + J_{18})] + B_{16}B_{17}B_{18}C_{18} \\ = (J_{16} + B_{16})(J_{16} + J_{17} + B_{17})(J_{16} + J_{17} + J_{18}) + B_{16}B_{17}B_{18}C_{18}$$

$$C_{14} = J_{15} + B_{15}C_{15} \\ = J_{15} + B_{15}(J_{16} + B_{16})(J_{16} + J_{17} + B_{17})(J_{16} + J_{17} + J_{18}) + B_{15}B_{16}B_{17}B_{18}C_{18} \\ = (J_{15} + B_{15})[J_{15} + (J_{16} + B_{16})(J_{16} + J_{17} + B_{17})(J_{16} + J_{17} + J_{18})] + B_{15}B_{16}B_{17}B_{18}C_{18} \\ = (J_{15} + B_{15})(J_{15} + J_{16} + B_{16})[J_{15} + (J_{16} + J_{17} + B_{17})(J_{16} + J_{17} + J_{18})] + B_{15}B_{16}B_{17}B_{18}C_{18} \\ = (J_{15} + B_{15})(J_{15} + J_{16} + B_{16})(J_{15} + J_{16} + J_{17} + B_{17})(J_{15} + J_{16} + J_{17} + J_{18}) + B_{15}B_{16}B_{17}B_{18}C_{18}$$

$$\text{If } C_{15-18} = (J_{15} + B_{15})(J_{15} + J_{16} + B_{16})(J_{15} + J_{16} + J_{17} + B_{17})(J_{15} + J_{16} + J_{17} + J_{18}) \quad (4)$$

$$\text{and } B_{15-18} = B_{15}B_{16}B_{17}B_{18} \quad (5)$$

$$\text{then } C_{14} = C_{15-18} + B_{15-18}C_{18} \quad (I)$$

Similarly, we can derive

$$C_{11-14} = (J_{11} + B_{11})(J_{11} + J_{12} + B_{12})(J_{11} + J_{12} + J_{13} + B_{13})(J_{11} + J_{12} + J_{13} + J_{14}) \quad (6)$$

$$B_{11-14} = B_{11}B_{12}B_{13}B_{14} \quad (7)$$

$$C_{10} = C_{11-14} + B_{11-14}C_{14} \quad (II)$$

$$C_{7-10} = (J_7 + B_7)(J_7 + J_8 + B_8)(J_7 + J_8 + J_9 + B_9)(J_7 + J_8 + J_9 + J_{10}) \quad (8)$$

$$B_{7-10} = B_7B_8B_9B_{10} \quad (9)$$

$$C_6 = C_{7-10} + B_{7-10}C_{10} \quad (III)$$

$$C_{3-6} = (J_3 + B_3)(J_3 + J_4 + B_4)(J_3 + J_4 + J_5 + B_5)(J_3 + J_4 + J_5 + J_6) \quad (10)$$

$$B_{3-6} = B_3B_4B_5B_6 \quad (11)$$

$$C_2 = C_{3-6} + B_{3-6}C_6 \quad (IV)$$

$$C_{0-2} = (J_0 + B_0)(J_0 + J_1 + B_1)(J_0 + J_1 + J_2) \quad (12)$$

$$B_{0-2} = B_0B_1B_2 \quad (13)$$

$$C_1 = C_{0-2} + B_{0-2}C_2$$

Substituting equations (IV), (III), (II), and (I) successively into equation (V), we obtain

$$C_1 = C_{0-2} + B_{0-2}C_{3-6} + B_{0-2}B_{3-6}C_{7-10} + B_{0-2}B_{3-6}B_{7-10}C_{11-14} + B_{0-2}B_{3-6}B_{7-10}B_{11-14}C_{12-16} + B_{0-2}B_{3-6}B_{7-10}B_{11-14}B_{15-16}C_{18} \quad (14)$$

From equations (1), (2), and (4)-(14) and the functions of the basic logic circuits, we can draw the level-by-level comparison circuit logic for comparing 2 19-bit binary numbers Q and X (see Figure).

Using this comparator circuit diagram, if we replace the input X by the input S, the output designation $\overline{Q} < \overline{X}$ by $\overline{Q} > S$, and the output designation $Q < X$ by $Q > S$, we obtain a comparator circuit for 2 19-bit binary numbers Q and S.

The multibit comparator has met design requirements in the course of several years' operation.

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MEMORY ERROR PROCESSING IN 757 COMPUTER

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[Text] Abstract. This article surveys the processing of memory errors in the 757 computer. In instantaneous-state single-bit errors, processing continues after the error is corrected, while in the case of instantaneous-state multibit errors or address errors, processing of an alternate program is begun. In the case of permanent single-bit errors, either they are corrected and processing continues, or a memory module is replaced and processing continues while error location is carried out for repair purposes. When permanent multibit errors or address errors occur, error location is performed; if a read error is involved, the module is replaced and an alternate program is run, while otherwise an alternate program is run without replacement of the memory module. If both backup memory modules are already in use, even in the case of a read error, the module replacement is not carried out. When there are permanent multibit read errors in all user programs, the system is initialized and disconnection and memory reorganization are carried out with the usable memory modules, after which the machine is restarted.

I. Internal Storage Module Replacement and Disconnection With System Initialized

The 757 vector machine's internal storage has a capacity of 520,000 words in 16 modules (Nos 0-15), together with 2 backup modules (Nos 16 and 17) to replace malfunctioning modules. Figure 1 shows the indicator bits for module disconnection and replacement in general purpose register No 7 (TN7). Bits Nos 49 and 54 are C_{B0} (backup module 1) and C_{B1} (backup module 2): a 1 in either of these locations indicates that the module in question has been substituted for a malfunctioning module. Bits 50-53 and 55-58 give the number of the module replaced by backup modules 0 and 1, respectively. If a module malfunctions after both backup modules have been used, it must be

disconnected, but in order to assure address continuity, at least four modules must be disconnected on each occasion; bits 59 through 62, respectively, indicate disconnections QT_0 (modules 0-3 disconnected when a 1 was present), QT_1 (modules 4-7 disconnected), QT_2 (modules 8-11 disconnected), and QT_3 (modules 12-15 disconnected). The computer can operate in three different disconnection modes:

1. modulo 16: at least 16 modules among Nos 0-17 operating normally;
2. modulo 8 + 4: four modules disconnected (either 0-3, 4-7, 8-11, or 12-15);
3. modulo 8: a maximum of 8 modules can be disconnected, and these must all be within the same group of 8, i.e., either 0-7 or 8-15 may be disconnected in modulo-8 operation.

The memory cannot operate with any combination other than the three named above. Bits 25-42 in TN7 correspond to the on-line switches for modules 0-17. The switches are located on the mainframe instruction control unit control panel. When any of them is depressed, the corresponding bit in TN7 is a 1. When the system is initialized the maintenance personnel must depress the on-line switches for all units which can be on-line, they carry out replacements or disconnections with reference to the switches. These operations are then fanned into TN7. Figure 2 shows the arrangements for the relevant program and the operating system. Figures 3 and 4 are system initialization program flowcharts.

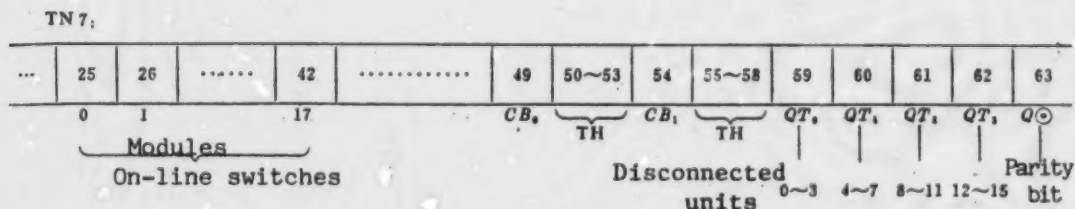


Figure 1.

Disconnection situation				Modular operation	Flag bit (L)
QT ₀	QT ₁	QT ₂	QT ₃		
0	0	0	0	16	0
1	1	0	0	8	2
0	0	1	1		
1	0	0	0	8 + 4	1
0	1	0	0		
0	0	1	0		
0	0	0	1		
Other combinations				not used	3

Figure 2.

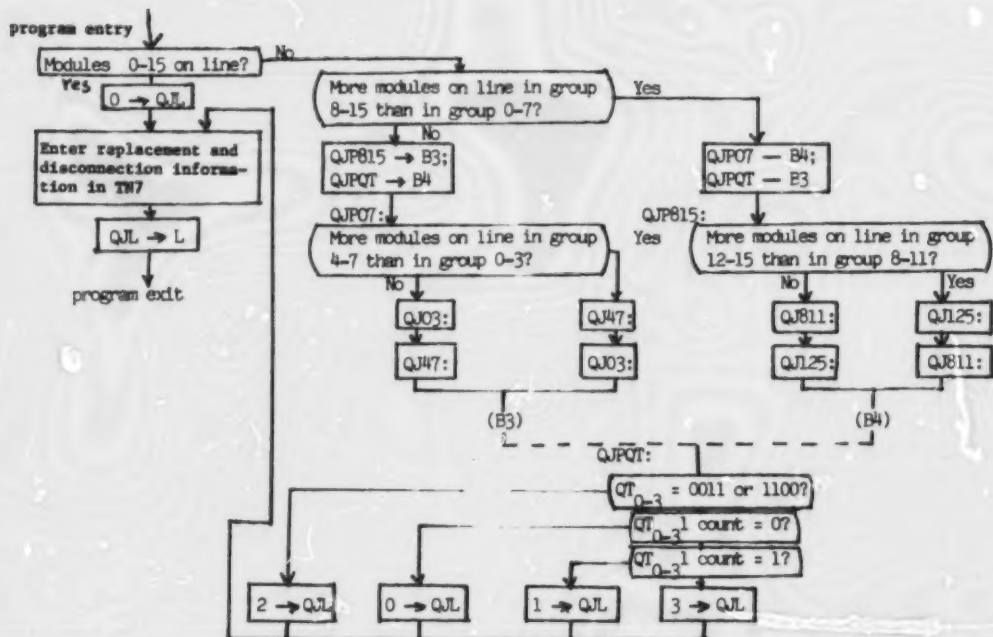


Figure 3.

II. Error Logging Table

Each time an error occurs, the type of error, the number of the module in which it occurs, the number of the incorrect bit, whether it is an intermittent or permanent fault, and the like, are recorded in the error logging table for reference. The error logging table occupies 512 locations (64 bits each) in page 63 of the peripheral processor memory; each time these 512 locations are filled, the contents are transferred to tape, after which the 512 locations are cleared and logging starts again at the beginning. The first location gives the year, month, day, hour, minute, and second of the error, and the time indicator (1, 1, 1) is set in bits 1-3. The error record proper is placed in the next location. When the next error is to be recorded, if the year, month, and day are the same as for the preceding error, then the error is logged in the next location; otherwise the time indicator is placed in the next location and the error record proper in the location following it. The log format is as follows:

Time indicator:

1 1 1	Year	Month	Day	Hour	Minute	Second
0 1 2 3 ~ 9 10	~ 25	26~33	34~41	42~49	50~57	58~63

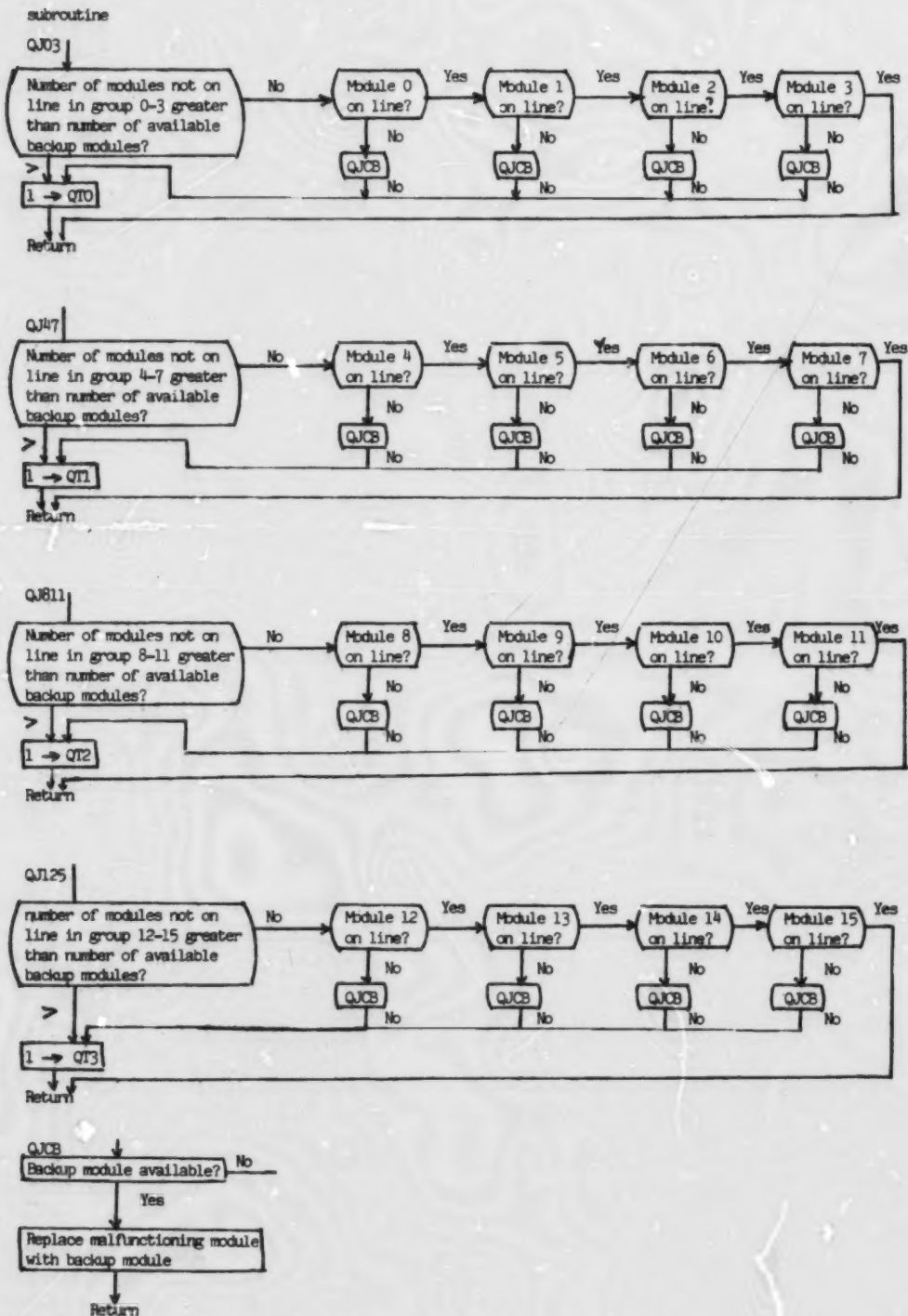


Figure 4.

Error record:

Control number	Error class	Error type	Replacement situation	Replacement number	Address error bit			Message display	Number of double calculations	Time of error	Recompute time
					Multi-bit error	Error bit 1	Error bit 2				
0~2	3~5	6~8	9	10 11~15	16	17~23	24~30	31~32	33~35	36~55	56 63

Control number: 100, memory error; 001, memory control unit error.

Error class: 001, internal store address error; 010, internal store data code double error; 011, internal store data code single error.

Error type: 100, address error; 001, write error; 011, single read error; 110, multibit read error.

Replacement situation: 00, no replacement; 01, replacement module 0 used; 10, replacement module 1 also used.

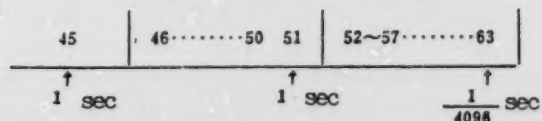
Error bit: when there is an internal storage address error, a 1 is placed in the corresponding position (0 to 14) to indicate bit 0 through 14. Two wrong bits can be recorded for a data code error: error bit 1 is recorded in positions 17-23, and wrong bit 2 in positions 24-30 (in binary form). If there are more than 2 wrong bits, then a 1 is placed at position 16.

Jitter: 00, jitter; 01, permanent fault, display message.

Number of double calculations: a number from 0 to 7; 7 indicates a permanent fault.

Time of fault: contains bits Nos 44-63 in time indicator.

Double calculation time: contains bits 50-57 of peripheral processor clock, indicating the following:



If the double calculation is too long for the space, then all zeroes are recorded.

The format of the signals sent to the operating system when there is an internal storage module error is as follows:

Bits		0	1	2	3	4~18	19~23
Fault class	One location	0	1	1	1	Error address	Unit in which error occurs
	More than one location	1	1	1	1	"	"
		0	1	0	0	"	"

III. Diagnosis and Processing of Internal Storage Address Errors

When an address errors, the message "NCDZCO" is produced in the memory control unit; the program recovers the number of the malfunctioning module and the address where the error occurred from the memory control unit and accesses this unit and the complemented address of the error (internal storage read); it then recovers the internal storage address and determines in which bit or bits the error occurred, waits 200 milliseconds, and accesses the module again. If the error disappears in fewer than seven accesses, then this is regarded as a temporary error; it is logged and a jump is made to the "nonrecomputable" entry so that an alternate program can be run. If the fault still persists after seven accesses, this is regarded as a permanent fault. It is logged and the following message is displayed in the following format (screen display):

```
NCGUZHA: XXXX. XX. XX. XX. XX. XX,  
COL: NCDZCO,  
COTH: X,  
COW: X, X, .....X,  
DENGDAIWEIXIU: X SPP;
```

This is interpreted as follows: NCGUZZHA: year, month, day, hour, minute, second. COL, error class: NCDZCO, internal storage address error. COTH: number of malfunctioning module, X. COW, bit in which error occurred. DENGDAIWEIXIU, awaits servicing. X, SPP, message displayed X times.

The maintenance personnel carry out the repairs indicated in the message, then type in a command on the supervisor console to return to the test program entry. If the test results indicate that the error is still present, the message is displayed again. If testing indicates no error is present, a jump is made to the "nonrecomputable" entry and an alternate program is run.

IV. Diagnosis and Processing of Single Error in Data Code

If there is a parity error in a data code during a read or write operation, then an internal storage read error (NCDZCO) or internal storage write error (NCXCO) message is emitted; during a read from internal storage, if there is a "read error stop," a data code single error (SMDCO) message is sent by the memory control unit*. When the internal storage produces a read error or write error message the machine is not stopped; after the memory control unit has emitted a data code single error message it stops the machine and runs an alternate program. It first must be determined whether a write error or a read error is involved, and whether it is a single-bit or multibit error. In the case of either a read or write error, provided that it is only a single-bit error,

*"Single error stop" can be set by switch or by the program. When the machine is not stopped for a single error, the error is either corrected by hardware or tolerated. Because a single-bit error may include a multibit odd-parity error, the problem of a wrong parity check arises. In addition, because of failure to eliminate a single-bit fixed error, it is fairly easy for a multibit error to arise.

the mainframe is restarted and processing continues after fault processing has been carried out.

A data code single error is a memory control unit error, and when it occurs the memory control unit is stopped in that same beat, while the instruction controller and operation control unit are stopped in the next beat, so that the look-ahead register (X), look-behind register (H), index buffer register (BH), and general register (TN), which are involved with the memory control unit, all proceed for 1 beat longer than it. In order to be able to start the machine and continue operation after error processing, it is necessary to carry out start-stop processing as follows.

1. Memory control unit start-stop processing*

① Recover state.

② Determine which instruction is in memory control unit station 6 (JM 6). If it is NC → X, or Y → X, or Yb → X, or CK → X, or NC → TN, or NC → BH, or NC → ZH, then a ZOCJM 6 pulse is emitted and this instruction is discarded.

③ The instruction in memory control unit stations 1 and 2 (JM 1, JM 2) are determined. If the instruction in JM 1 is an effective H → Yb instruction and T200 = 1, or if the instruction in JM 2 is an effective H → NC, or H → Q, or H → QY, or H → Y, or H → BH, and T300 = 1, then, depending on MD, the following are emitted:

i) when $T_B = 1$, then pulses Z 1 CYHi and Z 1 CZHi are emitted; ii) when $T_R = 0$, then ZOCKH, Z 1 CZHi, and Z 1 CYHi are emitted and 15 DRHi and DRJSHi pulses are emitted to back the look-behind register up 1 beat. Then, if CKH = 1, a Z 1 CKH pulse is emitted, while if CKH = 0, then ZOCKH is emitted (i = 0, 1).

④ If JM 2 contains an effective NC → X instruction and CJSX = 1, then depending on MD, 15 DRJSXi pulses are emitted to back the look-ahead register up 1 beat (i = 0, 1, 2, 3).

⑤ If JM 2 contains an effective BH → NC instruction and T300 = 1, then depending on MD, 15 DRBHi and JSBHi + 1 pulses are emitted to back the index buffer register up 1 beat (i = 0, 1, 2, 3).

⑥ If JM 2 contains an effective TN → NC instruction and T300 = 1, then 15 DRTD pulses are emitted to back the general purpose register up 1 beat.

⑦ The instruction in memory control unit station 3 (JM 3) is determined. If it is H → BH, then a ZOCJM 3 pulse is emitted to discard this instruction.

2. Processing of External Instructions

If an internal instruction is involved when the internal storage read error message is emitted (i.e., an instruction to exchange data with peripheral

*See articles on the 757 instruction set and the mainframe control units.

processor channels 0 or 1 or disk channels 0 or 1), a signal must be sent to the operating system so that the requisite processing can be performed.

For an NC $\rightleftharpoons$ WP₀ [internal storage and peripheral processor channel] instruction, a flag 3 is sent;

For an NC $\rightleftharpoons$ WP₁ instruction, a flag 4 is sent.

For an NC $\rightleftharpoons$ P₀ [disk channel] instruction, a flag 5 is sent.

For an NC $\rightleftharpoons$ P₁ instruction, a flag 6 is sent.

3. Processing of Write Errors

When reading from main memory, once the memory control unit sends a data code single error (SMDCO) message, it is first determined whether a write error is involved. The module number and address number in which the error occurred are recovered and sent to stations 3 and 5 (JM 3, JM 5) of the memory control unit, and the data code (all 1's or all 0's) is distributed to rewrite register (JCXS) bit Nos 0-71 (Nos 0-63 are the data code bits, and 64-71 are the check bits). Then an internal storage write access command is issued and the data code resulting from the write operation is recovered and examined for errors. If there is a write error, after a delay of 200 milliseconds another write operation is attempted. If the error disappears in fewer than seven accesses, it is again determined whether a read error exists. If a write error is still present after seven accesses, then it is a permanent fault; a determination is made whether it is a 1-bit or multibit fault, the fault is logged and a message is displayed.

(1) If it is a 1-bit fault, the message is as follows:

NCGUZA: XXXX. XX. XX. XX. XX. XX,
COL: NCSMDCO: CK $\rightarrow$ NCTDCO \ NCXSJCO;
COTH: X,
COW: X,
DENGDAIWEIXIU: XSPP;

Other than COL [fault class], the display is the same as for an address error. In COL, NCSMDCO indicates an internal storage data code single fault; CK $\rightarrow$ NCTDCO/NCXSJCO indicates memory control unit $\rightarrow$ internal store channel fault or data write register fault.

The maintenance personnel perform the indicated repairs, then type in a command on the supervisor console to return to the test program entry. If the test results indicate no error, then the status is restored and memory control unit start-stop processing is executed, the mainframe is started, and processing continues. If the test indicates that a write error still exists, the message is displayed again.

(2) In the case of a multibit fault, the display is as follows:

```
NCGUZA: XXXX. XX. XX. XX. XX. XX,  
COL: NCSMDOCO: CK → NCTDCO\NCXSJCO;  
COTH: X,  
COW: X, X, .....X,  
DENGDAIWEIXIU; XSPP;
```

Other than COL, this is the same as for an address fault. Under COL, NCSMDOCO indicates internal storage data code multiple fault. CK → NCTDCO/NCXSJCO indicates internal storage memory control unit → internal storage channel error.

The maximum number of bit-error indications [COW] that can be displayed is 72. The maintenance personnel perform the repairs indicated, then type in a command on the supervisor console to return to the test program entry. If the test indicates no error, a jump is made to the "nonrecomputable" entry. If the test still indicates a fault, the message is displayed again.

4. Processing of Read Errors

Once it is determined that there is no write error, all 1's are written into the internal store and a read command sent; then all 0's are written in and a read command sent. If the data codes that are read out are found to contain an error, then after a 200-millisecond delay another read from internal store command is sent. If the error disappears within seven accesses (this is the recompute number, which includes the total number of internal storage accesses for write and read) it is treated as a temporary error and logged, after which the machine status is restored and start-stop processing executed, after which the mainframe is started and operation continues. If the error is still present after seven accesses, it is necessary to determine whether it is a 1-bit or multibit read error.

(1) One-bit read error: it is necessary to determine whether a backup memory module is available and on line.

(i) No backup module available or no module on line.

After the error is logged, the following message is displayed:

```
NCGUZA: XXXX. XX. XX. XX. XX. XX,  
COL: NCTDCO;  
COTH: X,  
CODZ: XXXXX,  
COW: X,  
BTWAN; JINJIDAIXIU;
```

Differences from earlier message displays are as follows. In line 2, NCTDCO indicates internal storage module single error; in line 4, CODZ indicates the error address; in line 6, BTWAN indicates backup modules all in use, and JINJIDAIXIU indicates repair urgently needed.

After this message is displayed the return is made automatically without the need to type in a command, the state is restored and the mainframe continues operation. Because the single error is not yet removed, "single error no stop" must be set; the hardware corrects or tolerates the fault.

(ii) Backup module is available and on line:

The contents of the malfunctioning module, with the error corrected, are entirely transferred to the backup module, which then replaces the malfunctioning module; the latter is switched out and the maintenance personnel make the necessary repairs with it off line.

When the module is replaced, the number is entered in TN7, the error is logged, and the following message is displayed:

```
NCGUZHA: XXXX. XX. XX. XX. XX,
COL: NCTDCO;
COTH: X,
CODZ: XXXXX,
COW: X,
TOJIJIANXIU;
```

This display differs from the preceding ones in line 6, where TOJIJIANXIU indicates off-line repair.

After this message is displayed, the return is automatic; the machine state is restored, "single error stop" is set (so that if another single error occurs it will still be possible to stop the machine), and the mainframe is restarted. The maintenance personnel switch off the on-line switch for the affected unit.

(2) Multibit error: Although the mainframe cannot continue operation after a multibit error is processed, if a multiple-location error is not involved then other parts of the malfunctioning module can still be used and an alternate program can be run; accordingly a determination must be made whether a multi-location error is involved and the operating system must be notified of the module number, the address of the error, and whether it is a single-location or multiple-location error.

(i) Single-location error. It is determined whether a backup module is available and on line.

1) If no backup module is available or none is on line, the following message is displayed:

```
NCGUZA: XXXX. XX. XX. XX. XX,
COL: NCTPOCO;
COTH: X,
CODZ: XXXXX,
COW: X, X, .....X,
BTWAN; JINJIDAIXIU;
```

This differs from the preceding messages as follows. In line 2 [error class], NCTDOCO indicates an internal storage module multiple fault; the bit number given is full word length, a maximum of 72 bits. An automatic return is made to the "nonrecomputable" entry and an alternate program is run.

2) Backup module available and on line

The contents of the malfunctioning unit are entirely transferred to the backup unit, which then replaces the malfunctioning unit. The malfunctioning unit is repaired off line. After the replacement, the fault is logged and the following message is displayed:

```
NCGUZA: XXXX. XX. XX. XX. XX. XX,  
COL: NCTDOCO;  
COTH: X,  
CODZ: XXXXX,  
COW: X, X, .....X,  
TOJIIJIANXIU;
```

After the message is displayed, the return is made automatically; a jump is made to the "nonrecomputable" entry and an alternate program is run (because even though there is no error in the backup unit that has been substituted, the contents that were transferred contain a one-address multibit error which cannot be corrected, so that the only course is to run an alternate program). The maintenance personnel switch off the on-line switch for the malfunctioning module.

(ii) Multi-location error

The error is logged and the operating system is notified of an internal storage multibit error and multiple-location error. The following message is displayed:

PPDOCO:

```
NCGUZA: XXXX. XX. XX. XX XX. XX,  
COL: NCTDOCO;  
COTH: X,  
CODZ: XXXXX,  
COW: X, X, .....X,  
NCDODYCO;
```

The difference from the preceding displays is as follows. In the sixth line, NCDODYCO indicates a multi-location error. The return is automatic after this message is displayed: a jump is made to the "nonrecomputable" entry and processing is carried out by the operating system.

V. Diagnosis and Processing of Data Code Double Errors

If during reading from main memory the data code has an error in an even number of bits, then the memory control unit produces the data code double

error message (SMSCO). The diagnosis and processing of this error are the same as for a multibit data code single error.

VI. Processing After Repair of Malfunctioning Modules

1. If the malfunctioning module which has been taken off line for repair is one of Nos 0-15, after it has been repaired a suitable time during computation is chosen, the relevant on-line switch on the control panel is depressed, and an operator emergency notification is used to temporarily halt program operation. An "internal store repaired, restore" command is typed in on the supervisor console and the repaired unit is transferred to the program's module diagnosis (ZDT) entry. It is first tested to determine whether it actually is repaired.

(1) If the module is found to still have a fault, the following is displayed:

PCO:

NCGUZHA: XXXX. XX. XX. XX. XX. XX, COL: XIUTCO; COTH: X, CODZ: XXXXX, COW: X, X, ...X,
--

The difference from the preceding displays is as follows. In the second line (error class), XIUTCO indicates error in repaired module. The return is made automatically after this message is displayed; the state is restored and the mainframe is restarted and continues operation.

(ii) If the test finds no faults, then the contents of the backup module which is replacing this module are entirely transferred back to the original module, which is then put on line in place of the backup module, the state is restored, and computation continues.

2. If the module which has been repaired off-line is one of the backup modules (No 16 or 17), when repair is completed a suitable time in the course of operation is chosen, the relevant on-line switch is depressed on the control panel, and an operator emergency notification is used to temporarily stop operation. Then the "module repaired, restore" command is entered on the supervisor console and the number of the repaired unit is sent to the module diagnosis (ZDT) entry of the relevant program, in order to determine whether the module has been properly repaired.

(1) If the module is found to still have an error, the situation is handled as in the case of units 0-15, a message is displayed and computation continues.

(ii) If the module is found to have no errors, then the "single error stop" flag is set at 0 (so that if another single error arises during the computation the machine can be stopped and a branch made to the diagnostic program, since a backup is now available for replacement), after which the machine's state is restored and the mainframe is restarted.

3. After an operator emergency notification is entered for a repaired memory module, if the module number for the "module repaired, restore" command is typed in incorrectly on the supervisor console, the following occurs:

(i) if the number is that of a module from 0 to 15 and that has not been replaced by a backup module,

(ii) or if the number typed in is that of a backup module which is currently replacing some other module, then the following message is displayed:

MLCO:

MLCO

MLCO indicates a command error. After it is displayed a return to computation is made automatically.

VII. Program Flowcharts

Figures 5-9 are program flowcharts for the processing of internal storage errors.

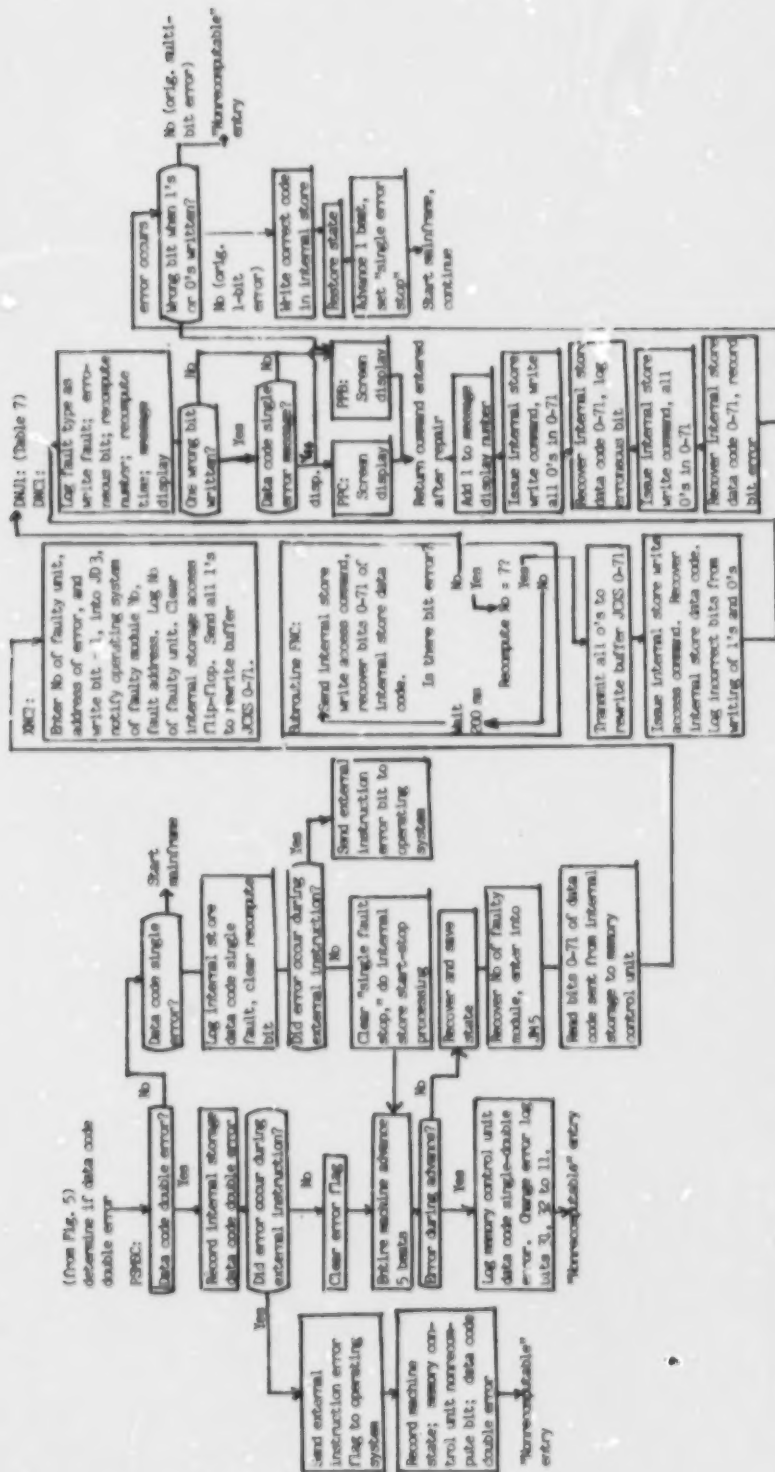


Figure 6.

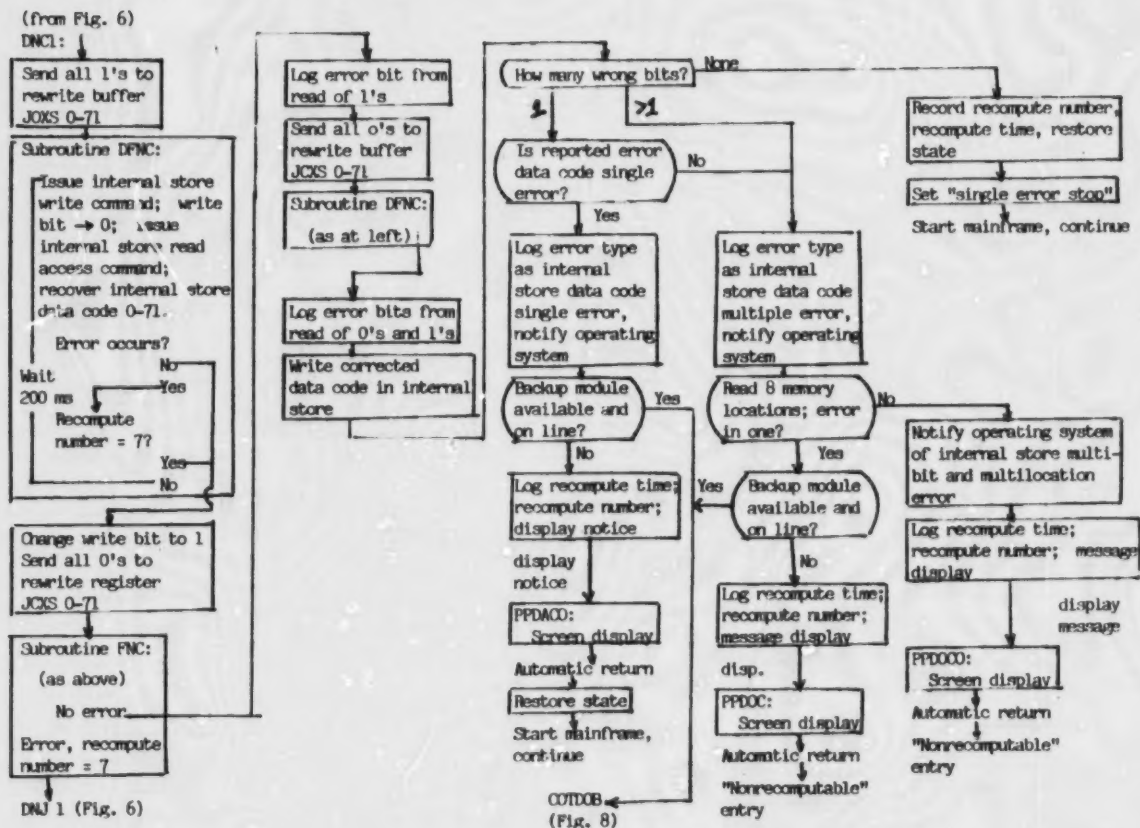
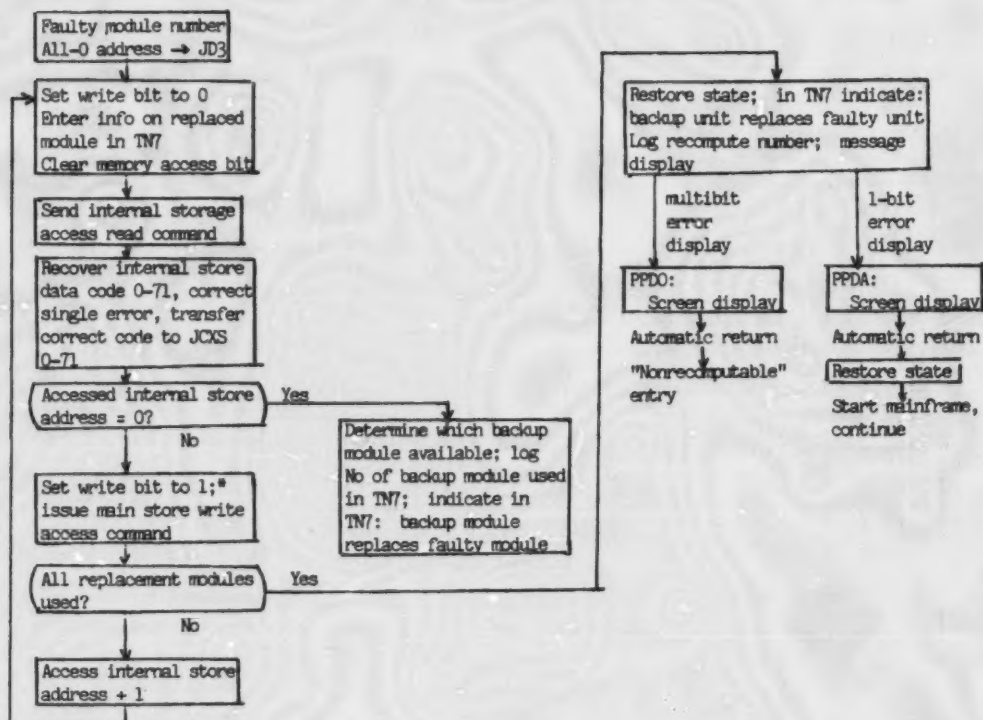


Figure 7.

(from Fig. 7)
COTDOB:



* Indicate backup unit replaces faulty module in TN7

Figure 8.

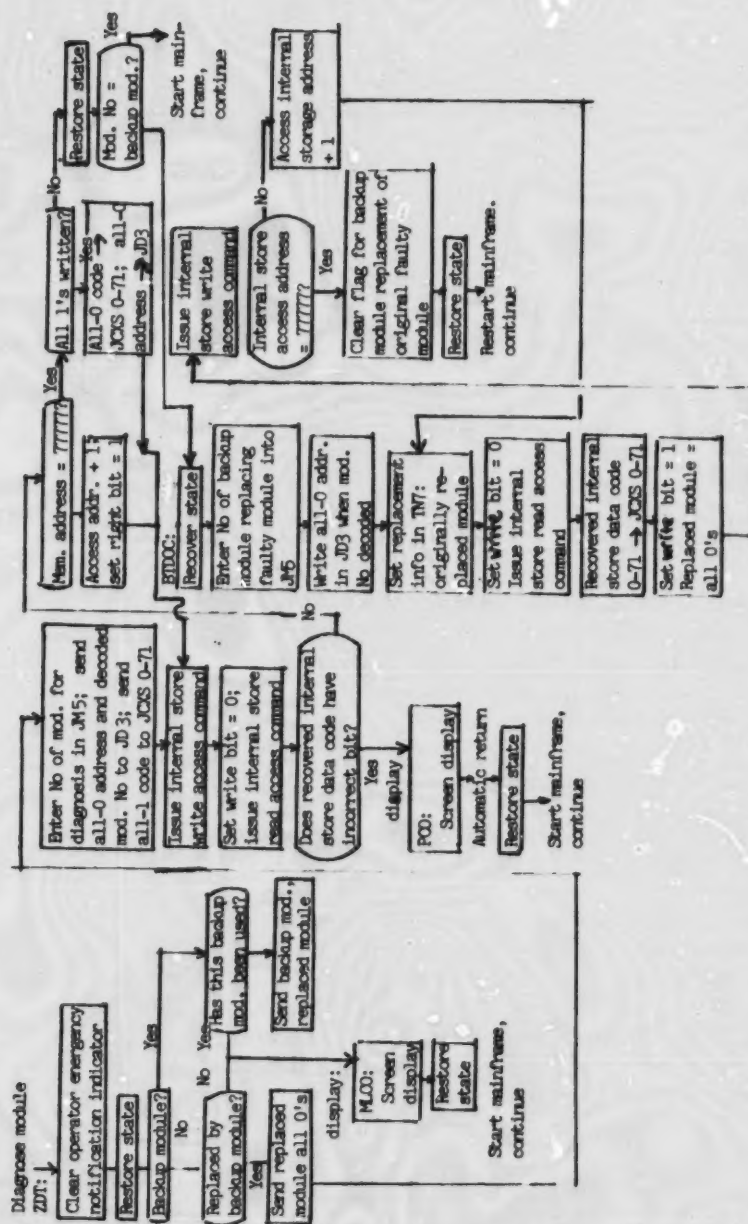


Figure 9

8480/9365
CSO: 4008/249

THERMAL DESIGN OF 757 COMPUTER

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER SCIENCE AND DEVELOPMENT] in Chinese Vol 21 No 3, 1984 pp 11-20

[Article by Tang Mali [0781 3854 7787], Tang Zhongchai [3282 6988 2088], and Li Minwang [7812 3046 2598], Institute of Computing Technology, Chinese Academy of Sciences]

[Excerpts] Abstract. This article compares the advantages and disadvantages of long-path and short-path forced-air cooling of computers. It briefly describes the three types of short-path ventilation design used in the 757 machine, simulation experiments, test results on the actual machine frames, the advantages and disadvantages of the methods, and matters to which attention must be directed when using this technique.

II. Thermal Design of the 757 Computer

The principles that were followed in the thermal design of the 757 machine are as follows:

(1) High reliability with a maximum junction temperature in IC packages not exceeding 85°C (maximum junction temperature for 500 mW bipolar semiconductor internal storage devices not exceeding 100°C), maximum junction temperature difference not exceeding 25°C; (2) simple construction, convenience of maintenance and management; (3) low noise and comfortable temperature in the computer room; and (4) subject to fulfillment of the above conditions, use of the smallest cooling system possible, in order to decrease production cost.

Choice of heat exchange method: Excellent cooling results can be obtained with conductive cooling using water or freon, but the design is complex, there are stringent requirements regarding machining precision, maintenance and management are complex, and manufacturing costs are high, so that this method was not used. Since the computer uses small-scale integration [SSI] circuitry, the individual packages have low power consumption, and convective forced-air cooling will meet heat dissipation requirements.

Choice between centralized or decentralized ventilation. Frames with centralized ventilation need not be equipped with blowers, which decreases noise in the computer room and makes it possible to decrease frame dimensions; in addition, relatively low temperature air can be fed directly into the frames, then, after cooling, allowed to escape into the machine room, so that the frames can operate at a relatively low temperature and the machine room will be comfortable.

Choice between long and short air paths: Short air path ventilation involves a simple design, there is no need to seal the front areas of the cards (and it is relatively easy to seal the air intake space), there are no air short circuits, uniform ventilation is easily achieved, and the maximum junction temperature and junction temperature difference are relatively low; in addition, because SSI circuits are used and the package power consumption is low, heat dissipation requirements can be met without high air speed. Choice between open- and closed-path systems. Air return ducts are not needed in an open-path system, which makes for convenience in layout and frame placement.

Based on the above considerations and the types of cards and boards used, we designed three short-path centralized open-path ventilation methods (decentralized ventilation was used for the peripheral devices, and each frame was equipped with a blower).

1. Thermal Design of Mainframe Internal Core Storage Frame, Peripheral Processor Operation Control Unit and Channel Frame, and Peripheral Device Controller Frame

The ventilation design shown in Figure 2 was used. Cold air passes from the bottom of the frame into the air intake space between two boards, then reaches the cards via air intake slots on both sides of the card connectors. After cooling the components it exits through the front of the card area and reaches the machine room through slots around the frame door. The heat in the power supply drawers is dissipated by sending air through holes in the air passage opposite the heat-sensitive parts and high-power consumption parts, after which it exits through the top of the frame.

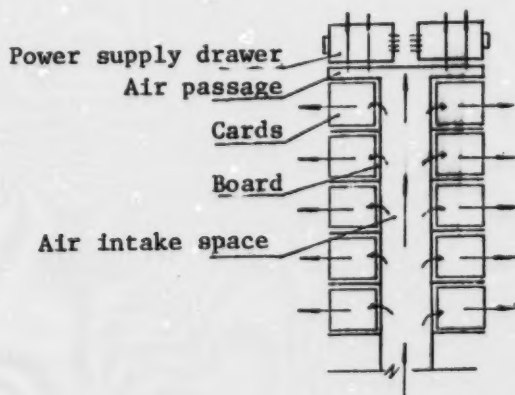


Figure 2. Short Air Path Ventilation, Type 1

Example: The thermal design of the mainframe core storage frame.

Each frame contains 92 circuit cards, each of which consumes 7 w; the cards are 26 mm apart, and the slots on both sides of the card connectors are 0.5 mm wide.

Each frame contains 100 control cards and amplifier cards, each of which consumes 2 w; the cards are spaced 17 mm apart, and the slots on both sides of the card connectors are 0.25 mm wide.

Each frame has three large power supply drawers, each with a power consumption of 110 w: 12 holes 12 mm in diameter are provided for each drawer.

Each frame has six small power supply drawers and each drawer is provided with five air holes 8 mm in diameter.

Calculation results indicate that when the static pressure in the air intake space is 2.2 mm H₂O, the flow rate in each frame is 400 m³/hour (the calculation procedure will not be described). The system has 18 vector processor internal core storage frames, which together take 7,200 m³/hr of air.

The ratio of the total area of card intake air slits and power supply drawer intake air holes Σf to the cross sectional area of the air intake space is $\frac{\Sigma f}{F} \approx 12$ percent; because this ratio is small, the speed of the air exiting through these slits and holes is uniform.

The advantages of this ventilation method are: 1) each card is uniformly ventilated; 2) the ventilation method is simple and easy to implement, and a large amount of ventilation hardware is not required; 3) the front section of the cards does not need to be sealed, which is convenient for machine adjustment and maintenance.

The disadvantages are:

(1) owing to the limited number of card modules, there is only a limited number of air intake hole sizes, and accordingly air intake slits are used for cards with different power consumption levels, so that their temperature rises differ at a given air flow,

(2) the widths of the slots must be made as small as possible in order to assure uniform airflow, and accordingly they may become blocked when dust collects on the cards, resulting in excessively high temperatures in the frames if they are not cleaned in time,

(3) when printed circuit boards are used, air slots cannot be placed on both sides of the card connectors, and thus this method cannot be used.

2. Thermal Design of the Peripheral Processor Core Storage Frame

The short air path ventilation passage design shown in Figure 3 is used.

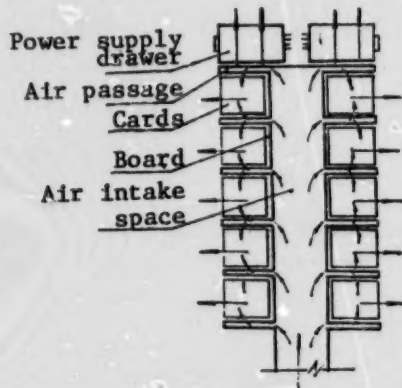


Figure 3. Short Air Path Ventilation, Type 2

The cards used in the core storage of the peripheral processor are large, measuring 520 x 480 mm. Three large cards form one 6-bit subunit, and 12 subunits form one 72-bit unit; each frame contains two 72-bit units. The three cards are a 48 w DC power supply card, a 23 w switching card (with an approximately 5 w core board on its back), and a 10 w amplifier card.

Because of the large size of the cards, there is a considerable power difference among the three different types. In addition, the power consumption of the components on an individual card is extremely unevenly distributed; it is low, and the slots relatively large, at the center of the cards, while power consumption is relatively large at the tops and bottoms of the cards. In terms of overall card layout, control cards (175 x 140 mm) are located between two rows of large cards. When using the conventional ventilation method, neither a long air path method with upward and downward flow nor a short air path with forward and backward air flow will meet requirements. A new method must be used so that each card in the frame and all components on the card will be in approximately equal ambient temperatures and so that the air flow rate will be minimized in order to assure a comfortable computer room environment. For this purpose we selected the design shown in Figure 7.

In this design, the air flows in through the bottom of the cabinet, enters the air intake space, then passes through the air passage and reaches the cards through round holes in the air passage; after the cold air flows over the components it passes out through the front of the card section, then exits into the computer room through slits around the door. Ventilation of the power supply drawers is the same as that used for the mainframe core storage.

Design of test cards. Resistors were installed on glass-reinforced plastic boards to simulate heat generation by the components. Three large cards,

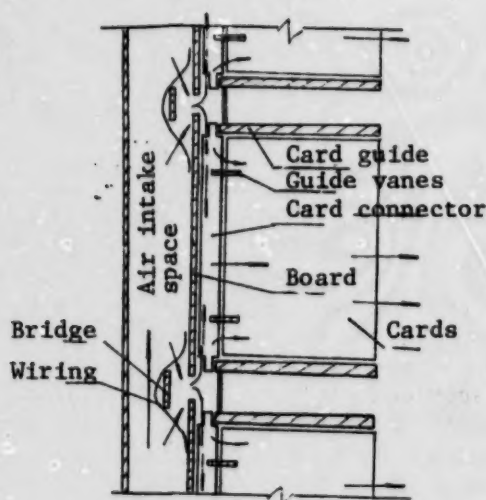


Figure 4. Short Air Path Ventilation, Type 3

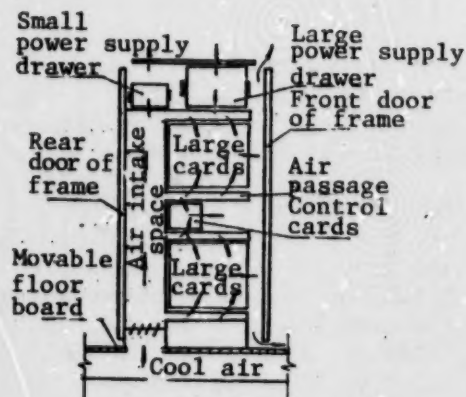


Figure 7. Ventilation of Peripheral Processor Core Storage Frame

the DC power supply card, the switching card, and the amplifier card, were installed in the test unit, spaced 28 mm apart. Figures 8 and 9 show the air flow results for the test unit with two different air flow designs. Either holes are uniformly spaced along the air passages, providing upward and downward ventilation of the cards (Figure 8), or holes can be spaced uniformly along the back edges of the card area at positions matching the boards to simulate flow through slits on both sides of the card connectors (Figure 9). When holes were drilled in the air passages, the real air speed was used. Because the cards are relatively tall, this type of air flow produces relatively serious problems in the air speed field along the cards.

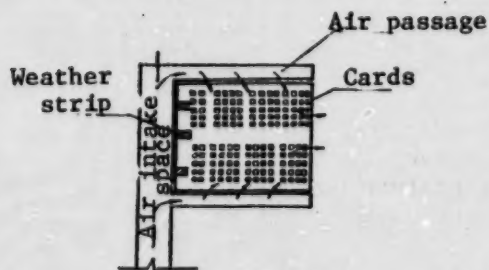


Figure 8. Experimental Unit for Ventilation by Top and Bottom Holes

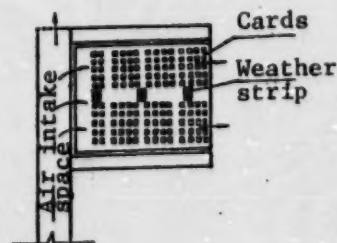


Figure 9. Experimental Unit for Ventilation With Holes in Back Plate

In order to assure that cards with different power consumption levels are in essentially the same ambient temperatures, the number of holes provided for each card is proportional to the card's power consumption level. Fifty-six round holes 4 mm in diameter were provided for the DC power supply cards,

40 holes 4 mm in diameter for the switching and amplifier cards, 10 holes 4 mm in diameter for the card boards, and 30 holes 4 mm in diameter for the 5 control cards.

For each card, the entering air first cooled the high-power consumption components at the tops and bottoms of the card, then cooled the low-power-consumption components in the middle of the card, so that each had a uniform temperature distribution.

In order to assure a uniform air speed through the small holes in the air passage, the principle of uniform air feed was used: because the main passages and side passages (i.e., the air intake space and air passages in this ventilation method) were of uniform cross section, as the air flowed through them the flow speed gradually decreased, so that the dynamic pressure gradually fell. If the local resistance and lengthwise resistance along the paths were relatively small, and were insufficient to compensate the dynamic pressure drop, then we find from the Bernoulli equation that the static pressure at the ends of the passages was higher than that at the beginnings of the passages, and accordingly the speed of the air exiting from the holes at the end was greater than that of the air exiting through the holes at the beginning of the passage. In order to equalize the speed of the air at the two ends of the passages, the ratio of the dynamic pressure to the total pressure must be decreased, i.e., the cross sectional area of the passage must be increased or the sizes of the holes decreased so that the exiting air speeds will be the same at all locations. But the dimensions are everywhere subject to the constraints of rational design and overall machine design, and accordingly the cross sectional dimensions must be calculated during design process and suitable values chosen.

Measurement Results

(1) Measurement Results From the Experimental Unit

(i) With the experimental model shown in Figure 8, holes were uniformly spaced in the air passage panels at the bottoms and tops of the cards; and the situations with and without baffles at the back of the card were compared. The baffles at the backs of the cards were used to prevent air short circuits and to make the temperature rise over the cards uniform. Figure 10(b) and Figure 11 show the ambient temperature on the cards and the temperature increase between the air entrance and exit.

(ii) Using the model shown in Figure 9, we spaced holes uniformly in the board at the back of the card area and compared the results obtained with and without baffles at the middle of the cards. Figure 10(a) shows the way in which the ambient temperature increases and the differences between the entrance and exit air temperatures are distributed over the DC power supply card. Providing baffles at the centers of the cards prevents air short circuits, so that the ambient temperature is fairly uniform over the cards. But because the power consumption at the tops and bottoms of the cards is high, while that in the middle is low, even with baffles added the temperature increases did not tend to become uniform.

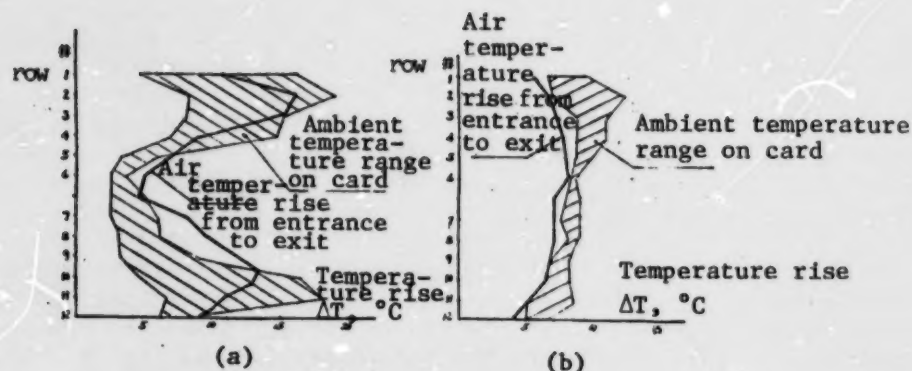


Figure 10. Temperature Rise on Cards, With Constant Air Source Flow Rate

- (a) Uniform hole arrangement in board;
- (b) Uniform hole arrangement above and below card.

Experimental conditions: card power consumption 48 w; 56 round holes 4 mm in diameter; static pressure in air intake space 3 mm H₂O; baffles added.

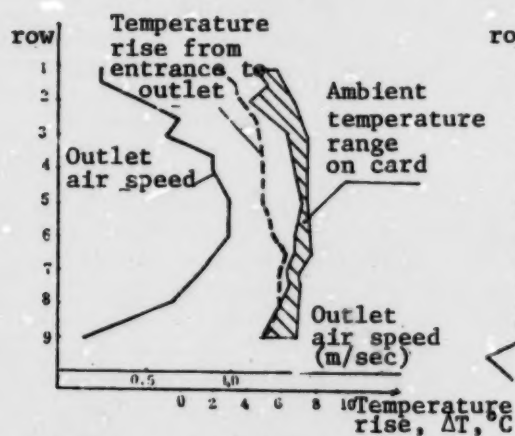


Figure 11. Temperature Rise on Experimental Switching and Amplifier Cards

Experimental conditions: card power consumption 23 + 10 = 33 w; 40 round ventilation holes 4 mm in diameter; static pressure in air intake space 3 mm H₂O; ventilation method of Figure 8 used.

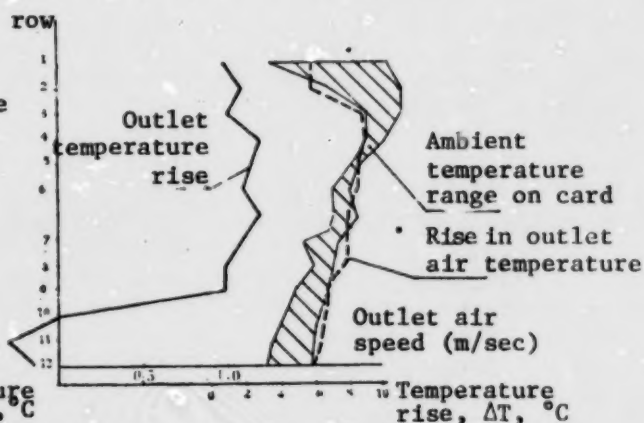


Figure 12. Temperature Rise on Actual Cards With Constant Air Flow

Experimental conditions: card power consumption 48 w; 56 air holes 4 mm in diameter; static pressure in air intake space 3.1 mm H₂O

(2) Test Results With Actual Frames

Figure 12 shows the distributions of the ambient temperature increase, the temperature rise from air inlet to air outlet, and the air outlet speed. This ventilation method was tested on actual frames and gave excellent results, with a uniform ambient temperature within the frame. Because the required ventilation air volume per watt of power consumption was only $0.3 \text{ m}^3/\text{hour}$, excellent heat dissipation results could be achieved with a low air flow rate. The low air flow rate means that the exit air speed is low and the exit air temperature rather high, so that service personnel in front of the frames will not feel cold. The design is simple; it is only necessary to control the number and distribution of the air holes and to choose suitable dimensions for the air passages and air intake space in order to effectively increase the uniformity of the temperature distribution.

The tendency for a uniform temperature distribution to develop over the large cards is also beneficial in this ventilation design because of the layout of the components on the boards. Therefore, when laying out the components, insofar as possible without degrading the interconnection capabilities, the air should be made to pass first over the high-power components, then over the low-power components; this will make the ambient temperature field on each board uniform. When the boards are in use, air short circuits should be prevented; an effective method is to place baffles on the boards. In addition, leakage from the air passages and air intake space should be prevented.

Use of baffles and prevention of leakage enable the cool air to be used with maximum efficiency and can increase the average outlet air temperature and produce comfortable conditions in the computer room.

With specific power consumption levels and air flow rates, we compared a design with air holes in the top of the air passage and a design with air holes in the back of the board (using 48 w DC power supply boards in all cases, with an air intake space static pressure of $3 \text{ mm H}_2\text{O}$, 56 round holes 4 mm in diameter per card, and baffles). The results are shown in Table 2.

Table 2. Comparison of Ventilation Techniques With Holes in Different Locations

Temperature rise		With air holes in air passage walls		With holes in back plate (actual cards)
		Experimental cards	Actual cards	
Ambient temperature rise on card (°C)	max	11.9	11.2	19.2
	min	5.2	3.2	2.4
	diff	6.7	8.0	16.8
Temperature rise from entrance to exit of frame (°C)	max	8.0	9.3	16.4
	min	3.8	5.5	3.8
	diff	4.2	3.8	12.6

Ambient temperature rise computations for the real boards indicated that the maximum temperature over a 375 mW triode would be approximately 58°C.

3. Thermal Design of the Mainframe Control Unit System

Because printed circuit boards are used in the frames for the mainframe unit's three control units, slots cannot be placed on both sides of the card connectors, and accordingly the ventilation scheme of Figure 2 cannot be used. In addition, because power cables enter through the guide areas, there is some inconvenience in using the ventilation scheme of Figure 3. As a result, we used the scheme shown in Figure 4. The fact that the printed circuit boards in the control units' frames are of floating type makes this ventilation method possible.

The system containing the three control units is in the form of a 12-sided polyhedron consisting of 11 frames and 1 door. Each frame has five small printed circuit boards, spaced 17 mm apart. The cooling air enters the air intake space in the 12-sided unit through a movable floor board, then flows through slots between pairs of small PC boards, then between pairs of card connectors, and enters the card area. After cooling the components, it exits from the front of the card section, then is exhausted into the computer room through slots around the doors of the frames (see Figure 13).

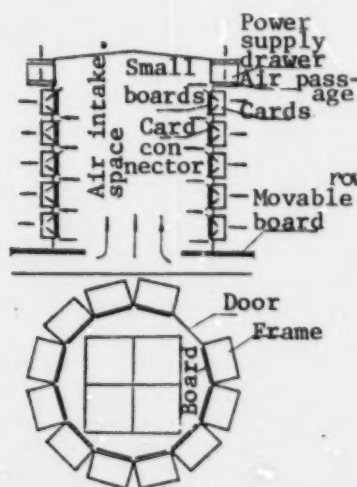


Figure 13. Ventilation of Three-Controller System of Mainframe

Simulation Experiment: In simulating the card, resistors were used to generate heat. Eighty were installed on each card. Figure 14 shows the way in which the temperature increases, and outlet air speeds are distributed over the card. It is evident from Figure 14(a) that the temperature distribution is highly nonuniform. When the cooling air flows around the card connector, because its flow speed is high, most of it flows along the slot between the two connectors, and when it reaches the center of the card it converges and flows out through the front of the card area; as a result,

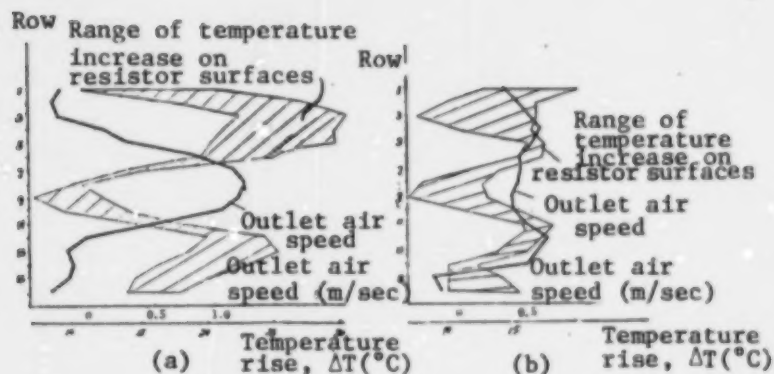


Figure 14. Outlet Air Speed and Temperature Rise in Three-Controller System Frame of Mainframe Unit

- (a) Without air deflectors
- (b) With air deflectors between connectors

Experimental conditions: static pressure in intake air space 2.8 mm H₂O (a) and 3.0 mm H₂O (b); card power consumption 15 w.

the flow speed is high when exiting from the central section of the card area, while it is low at the top and bottom, and suction develops. In rows 3-5 and 12-14 there are two high-temperature eddy areas. In order to make part of the air turn toward the front earlier, guide vanes were mounted between the two card connectors (shown in Figure 4), which decreased the temperature rise in the high-temperature eddy area so that the temperature distribution became relatively uniform over the entire card. Figure 14(b) shows the distribution of the temperature rise and air outlet air speed when the deflectors were added. It is evident from a comparison of Figures 14(a) and 14(b) that the deflectors provide a much more uniform exit air speed distribution, the suction in the upper and lower areas is alleviated and the temperature distribution becomes relatively uniform. Figure 15 shows the temperature rise for a 24 w test card.

Figure 16 shows the distribution of the temperature rise and exit air speed for an actual 15 w card. Figure 17 shows the effect of the signal cable cover on the temperature rise. It is evident that running the cable between the two small boards increases the air flow resistance, and that if the static pressure in the air intake space is not changed, too little air flows between the cards, and both the ambient temperature between the cards and the outlet air temperature rise somewhat, about 2-3°C. If the cables running between the two small boards are not pulled directly through, but instead are "bridged over" (see Figure 4), the air flow resistance is decreased and the temperature rise produced by the cable is relatively small, about 1°C.

As shown in Figure 16, calculations based on the ambient air temperature between cards and the thermal resistance of the IC packages indicate that the maximum junction temperature in a 375 mW high-speed shift register package is 63.5°C.

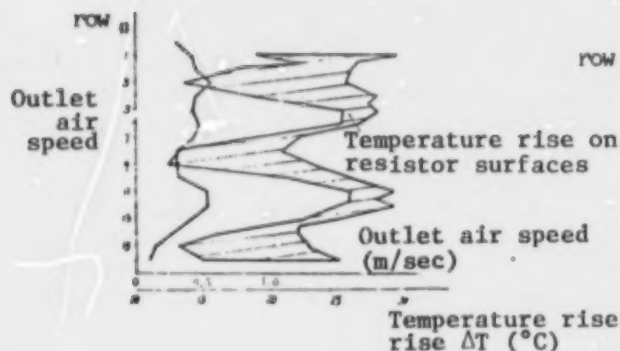


Figure 15. Outlet Air Speed and Temperature Rise for Test Cards of Mainframe Three-Controller System

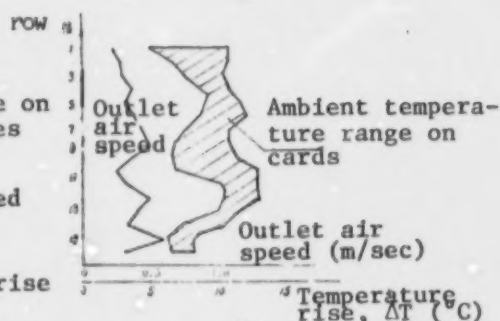


Figure 16. Outlet Air Speed and Temperature Rise on Actual Cards of Mainframe Three-Controller Units

Experimental conditions: Static pressure in air intake space 2.8 mm H₂O; card power consumption 24 w; deflectors between connectors; no power lines between small boards.

Experimental conditions: Static pressure in air intake space 4.6 mm H₂O; card power consumption 15 w; deflectors between connectors; 100 twisted-pair wires 0.6 mm in diameter run between small boards; no wiring bridge.

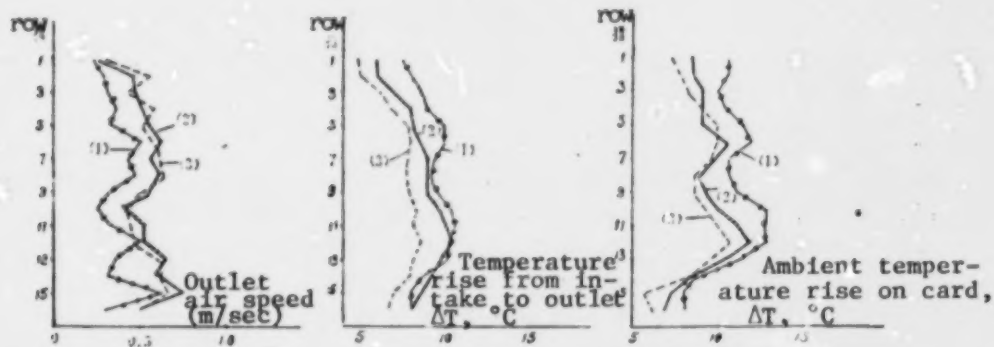


Figure 17. Effect of Wiring Between Small Boards on Temperature Rise and Outlet Air Speed in Three-Controller Frame of Mainframe Unit

Static pressure in intake air space 4.6 mm H₂O; card power consumption at 15 w. Curve 1, 100 twisted pairs 0.6 mm in diameter between small boards, no wiring bridge; Curve 2, 200 twisted pairs 0.6 mm in diameter between small boards, with wiring bridge; Curve 3, no wiring between small boards.

The ventilation method for the power supply drawers is the same as that used for the mainframe core storage power supply drawers.

The principal matters to which attention must be directed when using this ventilation method are as follows:

(1) The deflector dimensions and positions. The dimensions of the guide vanes and their positions and angles have a major effect on the air flow distribution. The dimensions and installation positions obtained in the experiments must be strictly followed.

(2) The air intake slot between the two small boards must not be blocked. If there is a relatively large number of connecting wires, either they must be "bridged across" or the space between the two small boards must be increased in order to assure that there will be sufficient air flow through the slot.

(3) Prevention of air leakage. The cold air which enters through the air space from the movable floor board must be permitted to pass only through the card area and must not short-circuit through other areas.

The air flow rates in the three control unit system of the mainframe are as follows: assuming a power consumption of 15 w per card, the rate should be $0.3 \text{ m}^3/\text{hour}$ for each watt. The three-control unit system of the mainframe has a total of 11 frames, each of which has 120 cards, and the total air flow for the cards is $6,050 \text{ m}^3/\text{hr}$. Together with the ventilation air for the power supply drawers, the total air flow rate for the control unit system of the mainframe is $8,250 \text{ m}^3/\text{hr}$; the static pressure in the air intake space is 6 mm H_2O .

Advantages of This Ventilation Method

(1) It is usable with printed circuit boards and with frames in which power cables enter through the guide area.

(2) It is simple in design; the only structural parts added for ventilation are the deflectors, the bridge, and the baffles in the small air passage for ventilation of the power supply. It is easy to install.

(3) With correct selection of the dimensions of the air intake space and the slots between the two boards, as well as of the positions and dimensions of the deflectors, uniform ventilation can be achieved and the temperature rise within the frame will be uniform. In addition, the problem of heat dissipation on relatively high-power cards (e.g., a power consumption of 24 w per card, with dimensions of 175 x 278 mm) can be solved with a relatively low air flow rate. Because the air flow rate per watt of power consumption is small (about $0.3 \text{ m}^3/\text{hour}$), the exit air temperature is relatively high and the area in front of the frames will not be cold, so that conditions in the computer room will be comfortable. If the front doors of the frames are open during adjustment of the computer, the ventilation results will not be degraded.

Disadvantages

(1) The amount of air fed to each card is about the same; the air flow rate cannot be varied in accordance with the power consumption of each card.

Therefore, the temperature increases are different on cards with different power consumption levels.

(2) The deflectors must be installed precisely, because their locations and dimensions have a major effect on air flow; in addition, care must be taken that wires passing between the two small boards do not block the air intake space.

4. Future Utilization of the Short-Path Uniform Ventilation Method

The short path uniform ventilation method may be expected to be used in frames with layout densities greater than that of the 757 large-scale machine. If the ventilation scheme of the control unit frames is used, constraints will result from the use of printed circuit boards and installation of the power cables in the guide spaces. In addition, provided that the air intake space is sufficiently large, the sizes of the air intake slots or ventilation holes can be increased as the power consumption of the IC packages is increased. Thus, without an excessively high air pressure, an increase in the air flow rate and the air speed over the components can be used to cool rather high-power cards. The control unit system of the mainframe consists of a polyhedron 2 m in diameter inside which is a large air intake space; this design decreases the length of the wiring used and creates excellent conditions for ventilation and heat dissipation.

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DESIGN OF ARITHMETIC COMPONENTS OF 757 VECTOR PROCESSOR PIPELINE

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 3, 1984 pp 21-28

[Article by Xu Jun [1776 3182] and Xu Kunming [1776 2492 2494], Institute of Computing Technology, Chinese Academy of Sciences]

[Text] I. Design Requirements

The 757 machine is the first pipelined vector processor designed in China; it uses a pipeline for all vector and scalar computations. As a result, a high arithmetic speed had to be achieved, and in addition to vectoring the computation problems, the single-flow pipeline speed had to be made rather fast. Furthermore, a great variety of vector pipeline operations had to be added to the vector pipeline, which posed stringent requirements regarding the design of the ALU [arithmetic-logic unit].

In order to design the 757's ALU as a technically advanced, high-speed, reliable device with economy of materials, we focused attention on the following points during the design process:

1. The arithmetic components can perform a total of 76 instructions, including 70 vector operations and 70 scalar instructions (not all instructions are usable for vector and scalar computations). Vector computations were made primary, with additional provision for scalar computations, and the speed of scalar computation instructions was maximized.
2. Because of constraints imposed by the current level of development of Chinese-made components, using all Chinese-made small-scale integration [SSI] circuitry (and a small amount of medium-scale integration [MSI] circuitry) to design the arithmetic components of a super high-speed large computer was technically rather difficult; the logic chain for each beat contained a rather considerable delay, which, together with the unavoidable wait time for entry of voltages into flip-flops, the load allocation serial gate time, and the clock pulse alignment deviation, made the number of logic levels actually usable in logic small. As a result, our only recourse was to focus on arithmetic techniques, logic forms, saving hardware and decreasing the number of levels in the logic chain.

3. We studied methods of expressing the numbers used in the computations, the choice of a coding system, and the roundoff method in ordinary [noncomplemented] code to see which choices would increase convenience and would minimize the chance of unnecessary computation errors resulting from rounding off.

4. In order to increase the reliability of the ALU, we designed a parity prediction-parity test system within the ALU, which was combined into an organic whole with recomputation and a diagnosis and location system, and made full use of RAS [reliability, availability, and serviceability] techniques.

II. Operating Principles of the Arithmetic Components

When the instruction control unit's (ZK) instruction buffer register discovers that the instruction fetched from the instruction buffer store is an arithmetic instruction, it immediately issues a fetch-store queue request to the memory control unit (CK) at the same time sending the data string length and the execution starting address in storage which has been determined by the instruction control unit's address adder; in addition, it sends the instruction to the operation control unit's (YK) instruction buffer station and changes the internal data store fetch or store address in it to the code given by the vector look-ahead data fetch buffer register (X_{0-3}) or the vector look-behind data store buffer register (H_{0-1}).

When the operation control unit (YK) receives the pseudocode from the instruction control unit (ZK), it passes through two buffer levels, fetching the pseudoinstruction which is stored in the buffer station to the pseudoinstruction buffer register and fetches two operands from the vector look-ahead fetch register or vector accumulator register (L_{0-11}) or other registers as specified by the contents of the instruction, then sends them to the ALU's operand receiving registers M and N; at the same time, it enters into the ALU's operation command receiving register Q the opcode Q, the vector component serial number F_g , the vector/scalar flag T_B , the arithmetic control value K, the address D of the vector look-behind store register or vector accumulator register which stores the result, and other relevant operational information such as the byte address, byte length, half-word floating point numbers and the like.

In the case of a vector instruction, this activity may be repeated as many as 16 times or as few as once; the number of beats separating the repetitions depends on the pipeline timing for each operation, which is determined in all cases by the "enable current" or "enable new" signal sent out by the ALU. The "enable current" signal enables only the components of the current vector instruction to be pipelined, while the "enable new" signal enables different instructions and different operations to be pipelined. If the operand for the new instruction has not yet arrived, even if the ALU has issued the "enable current" and "enable new" signals the operation control unit cannot send an operation command to the ALU, but must wait until the operand arrives; this is commonly known as a "dependent operation" and its flowchart is shown in Figure 1.

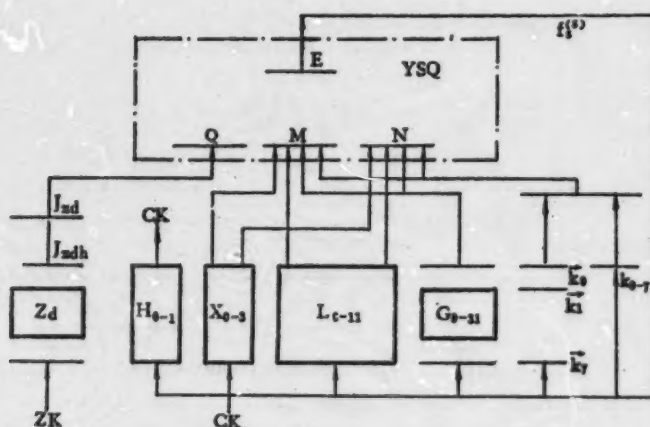


Figure 1. Block Diagram of ALU and Operation Control Unit

Accordingly, the ALU's flow of instructions actually can begin only after the instruction and the operand have both reached the ALU's receiving registers. The full pipeline in the ALU is divided into five stations; this is the longest pipe length, but not all instruction must pass through all five stations. More than 80 percent of the instructions can jump from station 1 to station 4, then pass through station 5. When a dependent operation arises, the result in station 4 can be shunted directly to M or N (i.e., $f_s^{(4)}$) in order to decrease the waiting time involved. For correctness, the arithmetic result still must be sent through station 5 in the normal manner so as not to affect the contents of the registers, as shown in Figure 2. Jumping of stations and shunting are both intended to maximize the performance of both scalar operations and dependent operations in the ALU. The basic capabilities of the pipeline stations are as follows:

1. Basic Functions of Station 1: 1) In floating point addition or subtraction, it finds the exponent difference from Q_1 and sends the larger exponent to A_j , the corresponding mantissa to the SBS register, and the mantissa of the smaller number to register B_s , the alignment number is sent to register A_s . 2) In multiplication, the partial multiplier (27 or 29 bits) is sent to A_s , the multiplicand is sent to B_s , and $\frac{3}{4}(B_s)$ is sent to the SBS register. 3) In division, the initial iteration number K for the divisor found from division table T_x is sent to A_s .

2. In Functions of Station 2. 1) It determines the partial products with carries eliminated. In the multiplier decoder YM_{0-9} , the control voltages ($KB, K_{\frac{1}{2}B}, K_{\frac{1}{4}B}, K_{\frac{3}{4}B}, KFB$) decoded for groups of 3 bits. The multiple gate BM that controls B_s selects nine decoded multiples and enters them in the truncated carry adder JFS, then finally finds sum H and carry number J . 2) It performs single-word or double-word alignment. The alignment uses a 1-beat method in which the fractional part can be shifted rightward by 0 to 63 places.

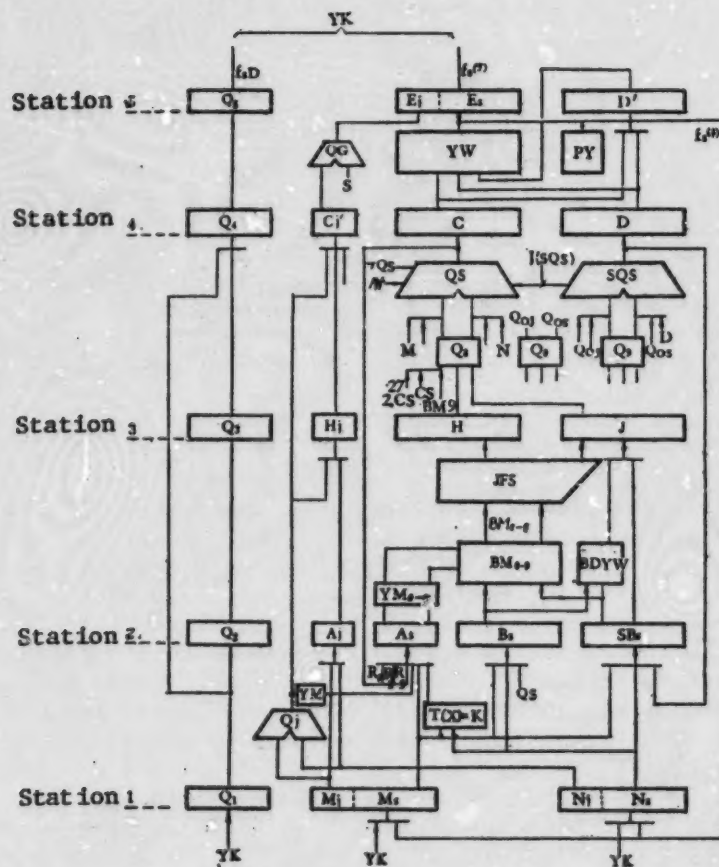
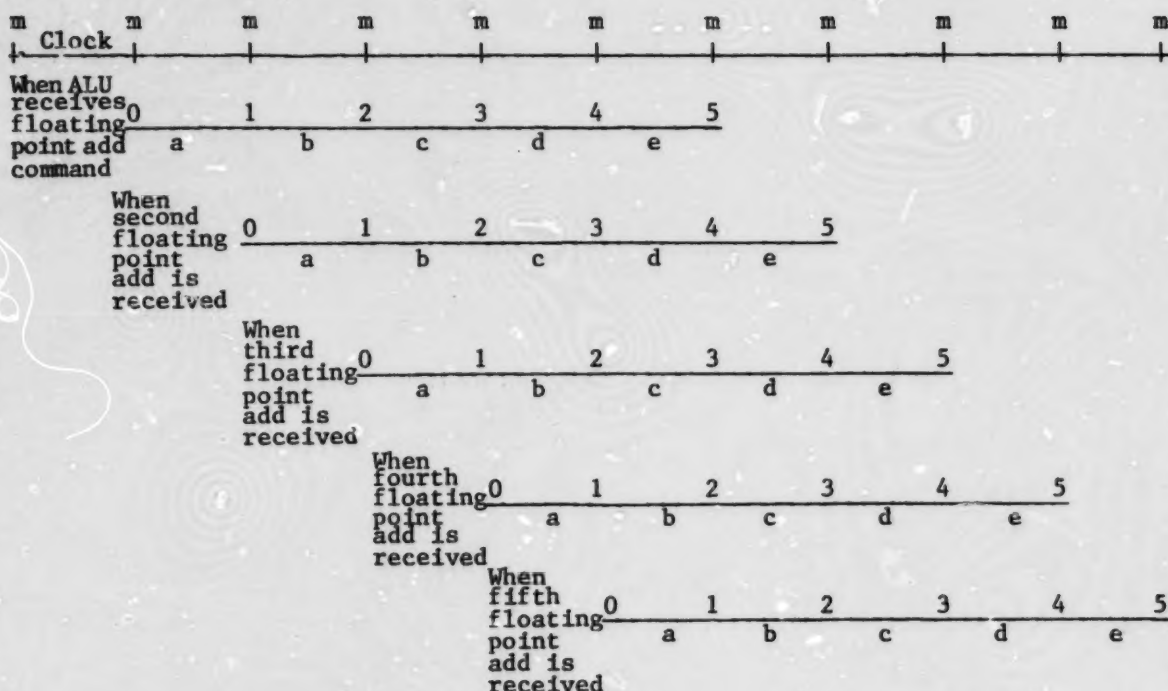


Figure 2.

3. Functions of Station 3. 1) It finds the partial and complete products from Q_8 , as well as the intermediate products in iterative division, sums, doubled values, and high-order bits of numbers, and performs complementation and radix-minus-one complementation and other logical operations. 2) It obtains three-fourths of the multiplicand from SQS, as well as triple intermediate results in division, the low-order part of the full product, doubled values, and low-order bits, as well as performing other operations.

4. Functions of Station 4. 1) It uses a shift circuit (YW) to shift and normalize single and double words (1 beat for single words, 2 beats for double words). 2) It uses a voltage combining circuit (PY) or shift circuit (YW) to combine half-word floating point numbers of 8-, 16-, or 32-bit integers into full-word-length numbers in the manner specified.

5. Functions of Station 5. 1) It tests computation results. The parity test bit of register E is used to test whether the results are correct, and if incorrect, a jump is made to the recompute routine. 2) It transmits correct



- Key: a. Find exponent difference (Station 1)
 b. Alignment (Station 2)
 c. Add and round off (Station 3)
 d. Normalize (Station 4)
 e. Transmit result (Station 5)

Figure 3. Overlap of Component Operations in Pipeline for Floating Point Add Vector Instructions

results. In order to increase reliability, the data code in E is formed into a 72-bit odd-weighted parity code for transmission, and the parity check of the data code sent from L or another register is made at the entrance to the ALU [Chinese abbreviation YSQ], if an error is found, the diagnostic interrupt routine can be used to make a soft correction of the odd-weighted parity code; thus a closed circuit redundancy is formed between the ALU and its peripheral registers, which effectively increases reliability. In particular, accumulator registers cannot be recomputed, but they can be corrected by means of the soft correction. 3) It transmits computation result time buffers.

As stated above, the results can be transmitted from f_s^4 of station 4, but there is insufficient time to transmit them from there to the accumulator or similar locations, since this cannot be completed in a single beat. This is why this station was added. Adding a station is not equivalent to adding time to the pipeline. For example, in scalar dependency, f_s^4 sends the results to M and N without loss of time, but in the case of a vector instruction, 16 component operations must flow through in a single instruction, and even at the

greatest flow speed, the next instruction still can start only after 16 beats; at this time the first component will long since have been completed, so that no loss of time will result from adding the fifth station.

Figures 3, 4, and 5 show the execution of vector operations in add, multiply, and divide instructions. It can be seen that all operations are executed with a high degree of parallelism and overlap, and all operations share all features of YSQ [ALU] to a rational degree, so that they can all operate in orderly fashion under pipeline conditions. The pipeline timing of each instruction must be carefully arranged, since either too fast or too slow a timing can produce collisions.

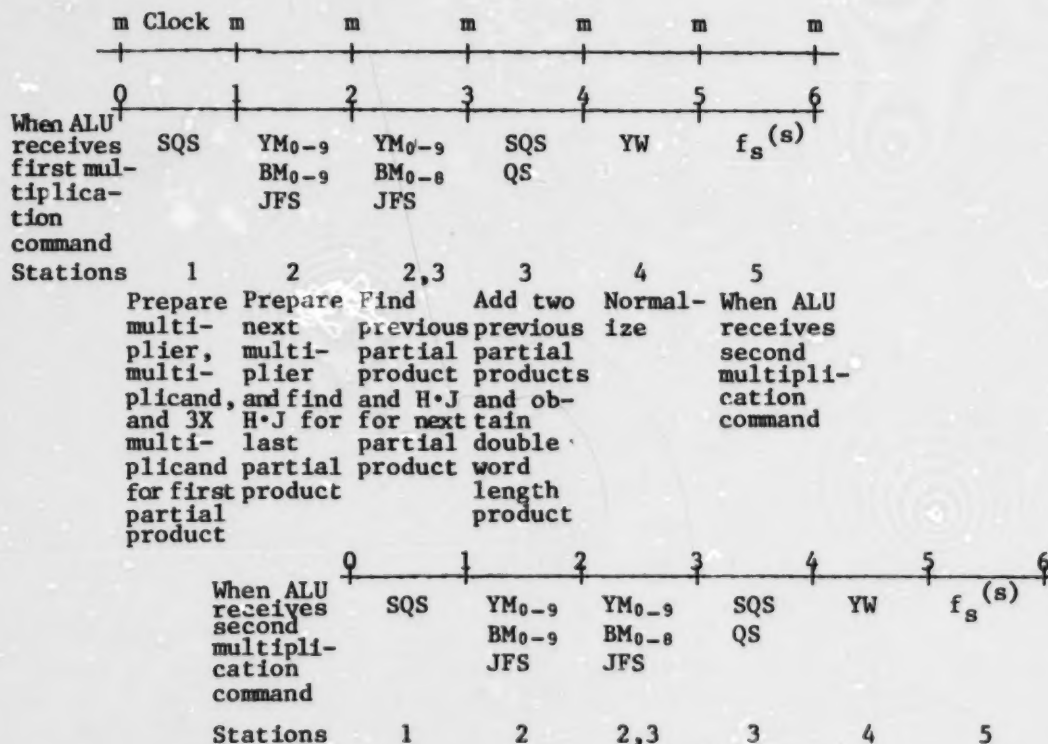


Figure 4. Overlap of Component Operations in Pipeline for Floating Point Multiply Vector Instruction

III. Number Representation, Choice of Coding Systems, and Ordinary Code Roundoff Rules

A computer's word length is determined by the type of problems to be processed, the storage capacity and the computing speed. When the 757 machine's word length was fixed at 64 bits, the topic with a major bearing in ALU logic design was the representation of full word length floating point numbers, half word length floating point numbers, and double word length floating point numbers. These three types are represented as follows:

1. Full word length floating point numbers

$$SF = 2^p \cdot s, \quad -128 \leq p < 127, \quad -(1-2^{-55}) \leq s \leq 1-2^{-55}$$

2. Half word length floating point numbers

$$SF_{1/2} = 2^p \cdot s, \quad -128 \leq p < 127, \quad -(1-2^{-23}) \leq s \leq 1-2^{-23}$$

3. Double word length floating point numbers

$$SF_2 = 2^p \cdot s, \quad -128 \leq p < 127, \quad -(1-2^{-110}) \leq s \leq 1-2^{-110}$$

In these representations, the exponent is represented in base-2 complement form and the mantissa in ordinary [uncomplemented] code.

The choice of base was made primarily in order to achieve maximum precision in the representation of half-word floating point numbers. Using base 2 or base 16 has its advantages and disadvantages, but based on considerations of implementation and familiarity, we continued to use the representation employed in the Model 109 (Mod 4) which we developed.

Very few high-speed computers represent data in ordinary code because when it is used for computations, if the difference is negative an additional beat of code conversion time is required, and when rounding off the ordinary code a relatively long end-around carry is necessary; as a result, all Chinese-made large computers use complement arithmetic. In the logic design of the 757 machine's ALU, because addition, roundoff, and code conversion can be carried out in a single beat of adder time, we changed over to the ordinary code representation (see section on adder logic design). Use of ordinary code has many advantages: it is relatively easy to understand, the absolute-value "round down at 4, round up at 5" method can be used, the error distribution is uniform, good symmetry is achieved, and relatively high computation accuracy is obtainable. In addition, normalization, shifting, and multiplication and division use simple logic and convenient operations and given an economy of hardware.

An example of rounding off:

$$\text{roundoff} = (C_{\text{opp}} + C_{\text{equal exp}}) \cdot J(Q_s)1/55 + C_{\text{equal exp}}(C_+ \cdot H_{56} + C_- \cdot H_{56})$$

where C_{opp} indicates that the two numbers entering the adder have opposite sign; $J(Q_s)1/55$ indicates bits 1-55 in adder Q_s with a carry bit in the highest-order digit; and H_{56} indicates the value of the roundoff bit H_{56} of fractional part H .

Example of handling of coding system:

$$\text{Complement } Q_s = -[C_{\text{opp}} + C_{\text{opp}} \cdot J(Q_s)1/55]$$

IV. Design Features

1. Full use is made of the ECL circuits' DOT-OR capability, with a clever logic design incorporating alternating positive and negative logic, thus saving hardware, decreasing the number of gate levels and saving level delay time.

2. With pipelining of vector and scalar operations, nondependent operations can be executed rapidly in the pipeline.

3. Because ordinary-code rounding off is used, the error distribution is uniform, with good symmetry and good computation accuracy.

4. The single-ALU design gives a high device utilization rate.

5. A special-design fast algorithm is used:

(5.1) Alignment in 1 beat, and 1-bit normalization ordinary-code roundoff floating point addition.

(5.2) Fixed point or floating point multiplication of 27-29 bits, 3 bits at a time in groups of 3.

(5.3) Precise iterative division with threefold iteration.

(5.4) Fast pipelined double-word floating point addition.

6. An end-around carry adder with ordinary code roundoff and a high-speed carry chain is used. Code conversions are all made in the adder, and accordingly there is no increase in the number of add beats, so that a full add uses only 7.5 levels. When this was engineered the actual time was 33-43 ns (including wiring delay; the gate delay time was 4 ns).

7. The ALU components have a rather complete and stringent test system.

(7.1) The parity prediction parity check testing method is primarily used, giving coverage of 95 percent or more. The device utilization ratio is rather low. The table below gives the component ratios in test systems that have been described in the literature.

Model		013	905	757
Unit				
Operation control unit		22%	18.1%	10%
Adder		30%	35%	<25%

(7.2) A closed protective Hamming code is formed outside the ALU, i.e., between the ALU and the accumulators, thus effectively assuring correct computation.

(7.3) Timely warning when a malfunction is detected, with recomputation, diagnosis, and location.

V. Execution Speed of Main Instructions

Type	Name of instruction	Beats to execute each scalar component	Number of beats in pipeline for each component	Remarks
Move	W $\rightarrow$ L, L $\rightarrow$ Y, Y $\rightarrow$ L, QCK h $\rightarrow$ L, K $\rightarrow$ h, L $\rightarrow$ G, L $\rightarrow$ BH G $\rightarrow$ D, D $\rightarrow$ L, O $\rightarrow$ L, L $\uparrow$ k $\rightarrow$ ko L $\rightarrow$ q	3	1	
Comparison	Find maximum	Scalar 6, vector 2L' + 6	2	
	Find minimum	Scalar 6, vector 2L' + 6	2	
	Maximum modulo x	Scalar 6, vector 2L' + 6	2	
	Minimum modulo x	Scalar 6, vector 2L' + 6	2	
	Larger than vector	Vector L' + 5	1	Vector operation
	Smaller than vector	Vector L' + 5	1	" "
	Equal to vector	Vector L' + 5	1	" "
	Smaller than comparison	3	1	
	Larger than comparison	3	1	
	Equal to comparison	3	1	
	Smaller than, modulo x	3	1	
	Larger than, modulo x	3	1	
Logical operations	K logical add	4	2	Scalar only " " " "
	K logical multiply	4	2	
	K bitwise add	4	2	
	Logical add	3	1	
	Logical multiply	3	1	
	Bitwise add	3	1	
	Complement	3	1	
Exponent code operations	Exponent add	3	1	
	Exponent subtract	3	1	
	Exponent code add immediate	3	1	
	Exponent code subtract immediate	3	1	

[continued]

[Continuation of Execution Speed of Main Instructions]

Type	Name of instruction	Beats to execute each scalar component	Number of beats in pipeline for each component	Remarks
	Exponent special shift	3	1	
	Exponent change to floating point	3	1	
Addition	Add	5	1	
	Subtract	5	1	
	Complement subtract	5	1	
	No-normalize no-roundoff add	5	1	
	No-normalize no-roundoff subtract	5	1	
	Special add	$L' + 4$	1	Vector instruction
	Double precision add	7	6	
	Double precision subtract	7	6	
Integer add	Integer	3	1	
	Integer subtract	3	1	
	Integer iterative add	$L' + 3$	1	Vector instruction
Multipli- cation	Normalized rounded multiply	6	2	
	Self multiply	6	2	
	Integer multiply	6	2	
	No-normalize no-roundoff multiply	7	2	
Division	Divide	12	8	
	Complement divide	12	8	
Shift	Integer left shift	3	1	
	Integer right shift	3	1	
	Left shift immediate	3	1	
	Right shift immediate	3	1	
	Integer double word length left shift	4	2	
	Integer double word length right shift	4	2	
	Immediate double word length left shift	4	2	
	Immediate double word length right shift	4	2	

[continued]

[Continuation of Execution Speed of Main Instructions]

Type	Name of instruction	Beats to execute each scalar component	Number of beats in pipeline for each component	Remarks
K operations	Determine K characteristic	3	1	No vector operation
	K → L	3	1	" "
	L → K	3	1	" "
Insert	Integer integer insert	L' + 2		Vector instruction
	Half word floating point integer address insert			
	Contract, store integer or half-word floating point			
Other	Count 1	67	1	Serial Serial beats) (3-67
	Count left 0	max 67		
	Change sign	3		
	Full word round off to half word	3		
	Separate integer, fraction	7		
	Separate integer to exponent	5		

Note: L' is vector length

VI. Conclusions

A long period of operation has indicated that the arithmetic components' main capabilities meet design requirements, and no major errors have shown up in the algorithms; one fairly major error has been the lack of special handling in division of zero by a nonzero number. A more efficient layout of the connections between the ALU and external components could make it possible to use higher frequencies. Because of the complexities attendant upon pipelined vector computations and insufficient experience in debugging of testing systems, there are still difficulties in debugging.

In terms of design there are two major deficiencies.

1. Little reserve potential. Because SSI circuitry was used to produce a high-speed pipelined computer, the wiring connections were too long and used up too much time. As a result, although the number of logic levels used up by each logic chain does not exceed the design requirements, time is still felt to be inadequate, which has hindered further increases in the working frequency. Two other factors also contribute to the long delay time in the wiring: one is the efficiency of the wiring layout, and the other is that the use of printed circuits in the computer increases the wiring delay time, so that in some locations the only way to decrease the time used was to make use of straight wires between points.

2. The high speed of the arithmetic components should be matched to the overall speed of the machine. Currently, the main factor affecting computation speed involves not the arithmetic components, but shifting, instruction fetch, and data fetch and store. Therefore, simply requiring that the scalar instruction execution speed of the ALU be increased will not have much of an effect on the machine as a whole. As soon as a scalar instruction appears, the ALU's waiting time becomes long. This is because a comprehensive view was not taken during overall machine design.

Above we have summarized certain design results involving the use of SSI circuitry to produce a high-speed pipelined computer, related to specific topics. In brief, the objective in designing the arithmetic components was to achieve a high level of capabilities and to make them into a rather technically advanced high-speed, reliable, practical ALU.

Other comrades who participated in the logic design of the 757's ALU included Comrades Wang Pixian [3769 0012 7341], Fu Chaoyuan [0102 2600 0337], Chen Dingxing [7115 1353 5281], Tian Gongxing [3944 0361 5281], Man Yunxia [3341 6663 7209], and Li Xiuying [2621 4423 5391], and subsequently Comrade Hou Qi [0186 0796].

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USE OF 5YCZ-72S CARD CONNECTOR IN 757 COMPUTER

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[Article by Chen Lizhong [7115 4539 1813] and Wu Fangyuan [0702 2455 0337], Institute of Computing Technology, Chinese Academy of Sciences]

[Text] The 757 computer is a large, fast general-purpose computer developed in its entirety with Chinese-made components and technologies. The machine contains a total of 12,000 connector sets, half of which are newly developed products such as the 5YCZ-72S card connector, the SJC-108 adaptor socket, and the like.

The 5YCZ-72S card connector, developed to meet the computer's assembly requirements, is designed for both plug-in and wire-wrap connection. Its development promoted the application and wider use of wire-wrap technology in computers. The 757 computer uses more than 5,000 of the connectors; their use in the machine has shown that they give good performance, have reliable quality, and meet machine requirements.

When this connector was developed, China had not previously developed one successfully. It had to meet not only general connector requirements, but also wire-wrap connection requirements. Accordingly, assuring its quality became one of the key problems in the development of the computer.

Below we describe the process of applying the 5YCZ-72S card connector in the 757 computer, focusing on user analyses of its capabilities and measurements of its quality both before and after it was incorporated into the computer and the requirements posed by its utilization.

I. Choice of a Design for the 5YCZ-72S and Main Technical Requirements

Because the 757 computer system is very large, has high performance standards, and uses a large number of connectors, and because the 5YCZ-72S card connector is used to connect cards to boards, the principal objective in its development was assuring its quality. Accordingly, we analyzed the design of widely used foreign and domestic connector springs and selected the "figure 9" design shown in Figure 1.



Figure 1. Shape of Spring Strip

This design uses material of variable cross section. Its main design dimensions are: wire-wrap tail of square cross section, $0.6 \times 0.6 \text{ mm}^2$; contact spring thickness 0.2 mm , width 1.8 mm , with 0.4 mm slot in center. The main advantages of this design were its good load-bearing ability and ability to regain its shape after deformation, its long life and rather stable insertion and withdrawal force and contact resistance. But the forming process involved in producing it was rather complex and difficult to automate, and some difficulty was involved in assuring uniformity of shape.

The main technical requirements were as follows:

Spring Strip Section. Total withdrawal force, at least 4 kg ; plug-in life, $1,000$ times; contact resistance, maximum 10 mohm during rated lifetime, maximum 15 mohm after rated lifetime; height of contact point, at least 2 mm ; contact stability: spring sections on both sides of central slot must be able to maintain contact with card leads; and surface plating, thickness $3\text{--}4 \text{ }\mu\text{m}$, in dense layer.

Wire-wrap Posts. Corner radius, minimum 0.04 mm , maximum 0.08 mm ; hardness H_V , $160\text{--}225$; flatness, maximum 0.05 mm in 10 mm ; and burr, maximum 0.02 mm .

II. Uniformity of Spring Shape: The Key to Quality

The shape of the spring strips in the 5YCZ-72S is complex, the precision requirements are high, and the process is difficult to automate; this poses problems for uniform shaping of the springs. But the degree of uniformity affects not only the appearance of the product, but also its quality and contact reliability. In order to increase spring uniformity, the following main processes must be stringently controlled.

(1) Precision of square wire and variation of thickness in flattening. As shown in Figure 1, the spring strips are formed from square wire 0.6 mm on aside that has been rolled from flat wire, and a section of which is then flattened, after which it is cut and subjected to several bending and forming processes.

It is evident from Table 1 that the precision of the square wire and its thickness variation have a major effect on the width after flattening; excessive variation in thickness will create differences in curvature and resilience when it is bent, thus affecting uniformity of shape. Rather large variations in width also affect centering in the subsequent cutting

of the slot. Accordingly, the precision of the square wire and the thickness variation on flattening must be stringently controlled. We used width grading to compensate for the effect of width variations, assuring that the slot was centered.

Table 1. Effect of Deviations in Thickness of Square Wire and Flattened Section

Deviation of square wire	Thickness deviation of flat section	Width change on flattening
± 0.01 mm	0	0.12 mm
0	± 0.01 mm	0.18 mm
± 0.01 mm	± 0.01 mm	0.30 mm

(2) The hardness of the strips must meet requirements. In order to eliminate stresses and brittleness produced by the flattening process, heat treatment is required; if the conditions are suitably chosen, the hardness requirements for wire wrapping will be met along with the elasticity and shape requirements for the spring strip. In addition, the hardness uniformity of each lot of spring material has a direct effect on uniformity of spring shape.

(3) Strict quantitative sample measurements in the forming process. Stringent control of the processes described above can steadily improve the acceptance rate in forming the spring strips, but it cannot completely eliminate nonuniformity in their shape. Accordingly, it is also necessary to make quantitative sample measurements during the spring forming process; we used comparison of magnified projections as a means of random monitoring of changes in spring shape. When the shape was found to be outside the permissible limits, the causes were immediately determined and steps to eliminate them were taken.

(4) Guaranteeing uniform positioning of spring strips in the connector body. This means correct alignment within the body, uniform height, and a suitable top pressure state. This is very important for the stability of the insertion and withdrawal force and the contact resistance. Therefore, we designed an assembly jig, shown in Figure 2. First the positioning piece makes the heights of the spring pieces flush and trues them up laterally. Then the assembly fixture securely clamps the tail sections of the spring pieces; with the body of the housing held immobile, the jig is pulled so that all of the springs are simultaneously inserted into the body in suitable positions.

III. Product Testing and Analysis

With reference to the Ministry of the Electronics Industry's general technical requirements for connectors, we established the following routine testing requirements based on our applications needs: 1) external inspection; 2) measurements of main technical characteristics under normal conditions:

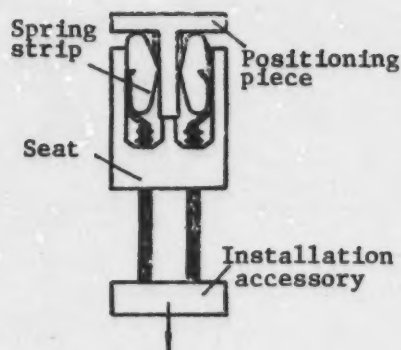


Figure 2. Installation of Spring Strips

Ⓐ wire-wrap technology characteristics, Ⓑ conventional connector technology characteristics, Ⓒ accurate position of holes in body; 3) high and low temperature tests; 4) humidity tests; 5) vibration tests: Ⓐ vibration strength, Ⓑ vibration reliability; 6) insertion and removal tests; and 7) tests of plating quality.

The wire-wrap technology characteristics include the strength of the wire-wrap posts, cracks, cross sectional shape, corner radius, shape of tip, flatness, burrs, torsional rigidity, and hardness.

The principal plating quality characteristics tested are the thickness and compactness of the plated layer. The samples are immersed in nitric acid, the time and place of appearance of a green color are observed, and the integrity of the plated layer is determined. The thickness is determined with a beta-ray thickness measuring device.

If the tests reveal quality problems, they are studied and methods of correcting them are determined.

In addition, the tests revealed the problem of a decline in the insertion and withdrawal force. It was particularly rapid in connectors with a high insertion and withdrawal force. We devoted major attention to this problem: did it involve the elasticity of the spring strips themselves, or other factors, and what effect did it have on connector performance? We performed a large number of computations, experiments, and analyses, principally the following:

1) Measurement of the relationship of contact pressure to contact resistance. When the spring was in contact with a printed circuit board in the direction of loading, with a continuous increase in the pressure we found that the contact resistance changed in accordance with the curve shown in Figure 3. This curve was used to determine the pressure range which gave a stable contact.

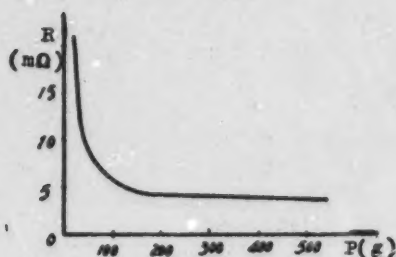


Figure 3. Relationship of Pressure (P) to Contact Resistance (R)

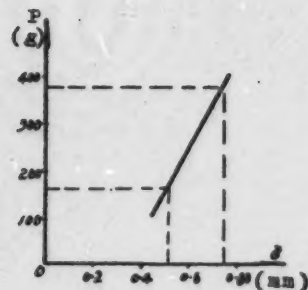


Figure 4. Relationship of Spring Deformation (δ) to Pressure (P)

It is apparent from Figure 3 that when the pressure exceeds 150 g the contact resistance becomes stable. The coefficient of friction on the plated surface is about 0.3, so that the withdrawal force for a single spring must be at least 45 g, and the total withdrawal force for an entire connector must be at least 4 kg. An excessive withdrawal force not only affects the spring's wear life, but also is unfavorable for its operation. According to our application conditions, while assuring reliable connections, it is desirable to minimize the total withdrawal force.

2) Calculation of spring loading and measurement of the relationship between spring deformation and applied pressure. Based on the spring's shape and dimensions, we calculated whether the pressure exceeded the elasticity limits of the spring material under normal conditions and whether it would be possible to assure a minimal contact resistance under the most unfavorable conditions. In addition, we measured the relationship of spring deformation to pressure, which is shown in Figure 4.

Under the conditions of actual use, the deformation of the spring was likely to be between 0.52 and 0.75 mm. It is evident from the curve that the pressure corresponding to this deformation range is 160-380 g. If the minimum pressure exceeds 150 g, a stable contact will be obtained. The calculated results agreed with measurements, indicating that the design was rational.

3) Monitoring of spring shape by projection. In order to monitor the reliability of the spring strips under maximum deformation, we removed eight strips from the ends and center of the connector body and used a projector to produce magnified images of their initial shape. They were then placed in the connector body and compressed until they were level with the spring seats. At specified time intervals the spring strips were removed and their projections were compared with the original projected shapes. After a year's measurements, the shapes of the springs showed no major changes, indicating that they had continuously remained within the permissible range of deformation.

4) Analysis of decay of withdrawal force. The above experiments and measurements showed that the decrease in the total withdrawal force did not result

from changes in the characteristics of the spring strips themselves; when it reached a certain range (not below the lower design limit), the decline in the withdrawal force leveled out. Accordingly we may assert that the decrease results from process factors and installation factors. In order to prove the correctness of the assertion, we tested connectors with a total withdrawal force of over 8 kg under the following conditions: I, careful selection of springs while removed from body, followed by reinstallation in the connector; II, removal of the springs, no selection, followed by reinstallation in the connector; III, springs not removed from original connector. The three test pieces were numbered I, II, and III accordingly. Insertion and withdrawal testing and storage gave the total withdrawal figures shown in Table 2.

Table 2. Reinstallation Comparison Experiment

Test piece	Remeasurement (kg)	Insertion-removal and storage tests (kg)							
		10 times	80 times	180 times	650 times	1,150 times	5 days	8 days	10 days
I	4	4.2	4	4	4	4.2	4	4	4
II	5	4.7	4.2	4.5	4.2	5	4.5	4.5	4.2
III	8	6.5	6	5.2	5	5.2	4.7	4.7	4.7

It is evident from the table that process factors and assembly factors directly affect the size of the initial withdrawal force and the extent of its decay.

5) Test of plug connection reliability and wire-wrap reliability. A general appraisal of comprehensive experiments on the wire-wrap performance of this product has already been made. In order to test the reliability of these two types of connections in use, we assembled a unit module equipped with 24 cards. The connection points and wire-wrap points of 48 connectors were connected in series by two paths. Each circuit had 1,344 plug connection points and wire-wrap connection points; a voltage was applied to them in a nonair-conditioned, contaminated environment. They were also subjected to impact and the cards were withdrawn and reinserted. At specified intervals the total resistance of each circuit was tested. After more than a year's monitoring, the total resistance of the circuits showed no significant change.

The above calculations, tests, and analyses enabled us to essentially master the main technical characteristics of the product and to meet design and use requirements so that it could be produced in lots for use in the computer.

IV. Comprehensive Testing Before Installation in the Computer

1) Choice of Tests. Even though the shaping and installation of the spring strips were subjected to rigorous control, we carried out comprehensive tests of their characteristics. In order to assure their absolute reliability, before installing them in the machine measurements also had to be taken on each connector. The measurements were as follows: ① correct height of contact points; ② contact of metal on both sides of slot with card leads.

We made a testing unit for testing each connector before it was installed, which gave excellent results.

2) Building the Test Unit

① Making the test head. The key element in the test unit is the test head. In order to test whether the metal on both sides of the slot is in contact with the card leads, we had to make a test head whose precision was greater than that of the cards. We divided each card lead into two leads separated by an 0.6 mm gap, resulting in a printed circuit test head with 144 lines. The production technology was the same as that for the printed circuit boards. The key was to select suitable match-up precision so as not to produce incorrect measurements. This test head was used to make tests on a 72-line card connector.

In order to screen out spring strips with a contact point below the specified height, the leads of the test head can be cut off at a certain height. For example, since we specified that the height of the contact point should be a minimum of 2 mm, we cut off the top 2 mm of the leads on the test head as shown in Figure 5. In this way, the springs with a contact point less than 2 mm high would not make contact with the test head.

② Testing method and circuit indication. The metal on the two sides of the slot in the spring strip was regarded as two series contacts corresponding to the two leads on the test head. The two connection points on each spring strip were connected in series with an indicator light by the leads on the test head, forming a circuit. Then the 72 spring circuits were connected in parallel, forming a circuit, as shown in Figure 6.



Figure 5. Test Head

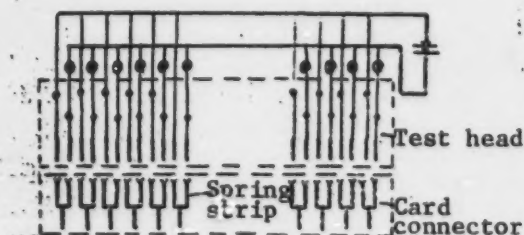


Figure 6. Test Circuit

When the test head is inserted into the connector, if both sides of the slot on the spring can contact the corresponding leads and the height of the contact points is at least the specified value, the corresponding indicator lamp lights and the spring passes the test. If the indicator lamp does not light, at least one side of the spring does not contact the test head or the contact location is too low, and this spring thus does not meet requirements. The number of the indicator lamp indicates which spring should be replaced.

This test unit was used to test all 72-line connectors before installation; the pass rate was high, and we were able to test 200-300 connectors an hour, with excellent results.

V. Use Requirements

Stringent quality measurements, tests, and analyses aimed at assuring reliable functioning of the connectors constitute one aspect of the problem; the other is their rational utilization and operation. These two aspects must both be taken into account in close association. Products which have been accepted but which are not used or operated properly are capable of causing product damage and malfunctions. There are many instances of this type. Accordingly, we established several requirements regarding the operation of the 72-line connectors.

(1) Stringent control of variation in the curvature and thickness of the cards during their production. The 757 computer's cards use a double 72-line insertion edge; they measure 278 mm (high) by 176 mm (wide) by 2.3 mm (thick) and consist of eight printed circuit layers as shown in Figure 7. With such large dimensions, there is a need for stringent control of their curvature and thickness tolerances during production. If these factors are too great, not only is the service life of the cards decreased, but there may be excessive variation in the contact pressures of the springs, which will affect their insertion and withdrawal and decrease connector service life. If the thickness is insufficient, poor connections may result. The design specifications are that along the greatest card dimension the degree of warping must not exceed 2 mm, while the thickness tolerance may not exceed ± 0.1 mm.

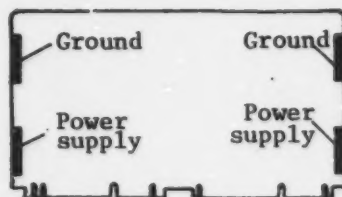


Figure 7. Card

The chamfer size of printed circuit cards affects the insertion force and spring wear. Because the contact points of the 72 springs are rather low, the chamfering of the cards must not be too great. The design requirement is that it be 0.5 mm x 45°. The cards must not have burrs or edges overlap.

(2) Special tools must be used for insertion and withdrawal. The 757 computer's boards consist of 5 board modules, each of which can hold 24 cards, as shown in Figure 8. The cards are inserted from the front along a horizontal guide. In the guide slots are spring strips serving as ground and power supply. Thus, special tools must be used for insertion and withdrawal to insure that the cards go in smoothly.

(3) Assuring centering of card and connector. It can be seen in Figure 8 that when the card begins to pass down the guide slot, it passes over the ground and power supply springs and moves into the connector. The guide slot system's ability to center and align the card and connector and to maintain the card in a central plane affects the connector's ability to provide

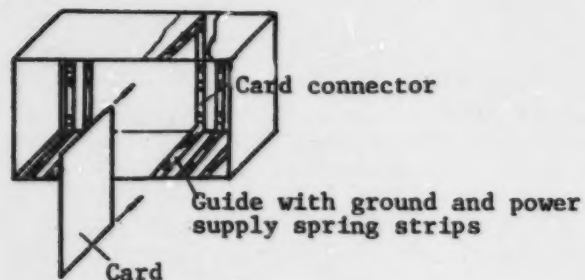


Figure 8. Board Module

reliable contact. Therefore, in designing and producing the board modules, we not only had to use special installation jigs and stringently control the precision with which the modules were assembled, but also had to use high-flexibility, low contact pressure springs as the ground and power supply springs. In this way the ratio of their clamping force on the cards to the contact pressure of the connector on the cards was relatively low. When a certain level of misalignment develops, the contact force of the connector on the card can cause it to float so that it meets the alignment requirement.

VI. Conclusions

The connectors are extremely critical components in the assembly of the computer, which have a key influence on overall machine performance. As computers develop, there is a need for continual adoption of new connection technologies and development of new connectors. How can one assure that a new product will function reliably in the computer? Our experience shows that it is very difficult for routine tests to reflect the overall picture of a product's capabilities, and we must perform thorough, detailed analysis and study of the product's material, the forming of its components, plating, assembly, and the like. In order to improve the reliability of connectors, not only must the producing plant make a stringent effort in product quality control, but the user must cooperate closely, e.g., by taking pains in rational selection and correct use of the product.

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MULTILEVEL PRINTED CIRCUIT BOARDS OF 757 COMPUTER, THEIR PROCESS DESIGN

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[Text] I. Survey

The 757 computer is a 10 MIPS [million instructions per second] large, general-purpose computer. The requirements for its printed circuit boards are high-quality electronic performance, high density, and high reliability. The small-area multilayered boards previously used as cards, using twisted pair wires as connections between boards, and with hand-applied wiring, were no longer satisfactory, so that it was necessary to use a new board design and a new manufacturing process. Analysis and trial manufacture led to the design of a multilayer board for the 757 machine and a new production process. It has the following main characteristics: 1) A large-area 8-layer board with 72 leads is used for the cards, with 12 cards installed on a multilayer PC [printed circuit] board forming a unit; the units are connected by the wire-wrap technique. 2) CAD [computer aided design] is used for automatic wiring layout, and the boards are produced with numerically controlled photograph scanning, numerically controlled hole drilling, and numerically controlled board testing. The production line uses the adhesive film reverse plating method. The new techniques involved include ① Roller application of a positive light-sensitive emulsion; ② Roughening of the inner copper pattern layers of the multilayer board and use of presoaked epoxy dicyonamide sheet to bond the layers. ③ An adhesive film photoresist process and alkali copper chloride etching. ④ Bright electroplating with tin-lead alloy. ⑤ A multilayer board system positioning process. 4) The effect of dual in-line package [DIP] pinhole soldering and die cutting of the board outline on plated through holes was studied. 5) Quality control and testing were used during manufacture of the multilayer PC boards, resulting in an acceptance rate of up to 85 percent. This design went into production, and about 2,000 multilayer cards and about 100 boards have been produced for the 757 machine, satisfying all of the specifications laid down in advance for the computer.

II. Design of Multilayer Circuit Boards

1. Data for Design of Boards and of Manufacturing Process

- (1) Satisfaction of high-speed transmission electrical requirements. In order to achieve impedance matching throughout the system and decrease power consumption, it was required that the entire machine have 90-ohm impedance matching and that the PC cards and boards have the same impedance; that the entire machine have a high-quality grounding system; that crosstalk between the signal lines in the multilayer board be kept within permissible limits; and that signal delays on the boards should be small.
- (2) Solving the problem of lack of impedance matching and excessive density in past board wiring. The multilayer PC cards in the Model 013 had a characteristic impedance of 80 ohms, while the boards used twisted pair wiring with a characteristic impedance of about 110 ohms; thus the impedances of the cards and boards were not matched to each other. Use of twisted pair connections doubled the amount of wire used; after soldering, the wiring was about 10 cm thick, and even thicker at turns on U-shaped boards, which created difficulty in soldering, checking the lines and repairing them. The level of interference between lines on a board was high, and it was difficult to automate their production.
- (3) Overcoming the deficiencies of the previously used hand-applied-wiring method of board production. Originally the wiring was done manually and involved a great deal of pattern application, with poor accuracy. With flow-on film application, the film clogged the holes when they were drilled, thus degrading the reliability of hole plating, and in addition the large amount of cutaway work involved in board wiring created the danger of cut-throughs, producing short circuits or exposing the glass reinforcing cloth weave so that the surface insulation resistance decreased.
- (4) The 757 machine uses dual-in-line packages (DIP) whose pins must pass through pinholes for soldering; this replaces the adhesion soldering of the earlier flat IC packages. In addition, 72-lead card connectors are used instead of the earlier pin-type plug connectors, creating stringent requirements regarding the bow and twist of the boards and their thickness tolerance.
- (5) The 757 machine uses small numbers of a large variety of cards; they are produced in large quantities and their production involves several difficulties, making it necessary to consider board standardization in production.

Our board design and process design focused primarily on solving the above problems.

2. Shape and Characteristics of Multilayer Cards

Card area: $175 \times 278 \text{ mm}^2$; number of layers, 8; thickness, $2.3 \pm 0.15 \text{ mm}$; order of layers, see Figure 1; hole diameter, 0.9 mm; ratio of board thickness to hole diameter, 3.

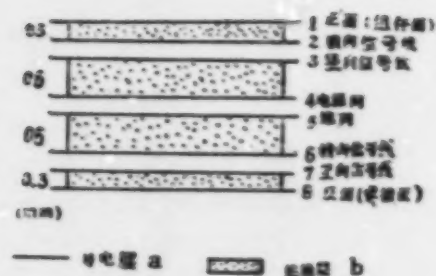


Figure 1.

Key:

- | | |
|----------------------------|----------------------------|
| 1. Front (component side) | 6. Transverse signal lines |
| 2. Transverse signal lines | 7. Lengthwise signal lines |
| 3. Lengthwise signal lines | 8. Back (solder side) |
| 4. Power supply network | a. Conductive layer |
| 5. Ground network | b. Insulation layer |

Soldering pads: Outer layer, $1.7 \times 1.7 \text{ mm}^2$, inner layers $1.5 \times 1.5 \text{ mm}^2$.

Signal line width 0.25 mm (about 0.2 mm after etching).

Coordinate lattice spacing: crosswise 2.5 mm ; vertical 3.75 mm .

Wiring density: 1 line in 2.5 mm spaces; 2 lines in 3.75 mm spaces.

Automated wiring coordinate spacing, 1.25 mm , for actual subdivision method see Figure 2(a), 2(b).

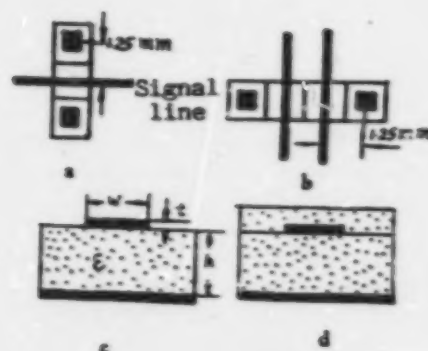


Figure 2.

Layout and dimensions of ground and power supply network layers: see Figure 3.

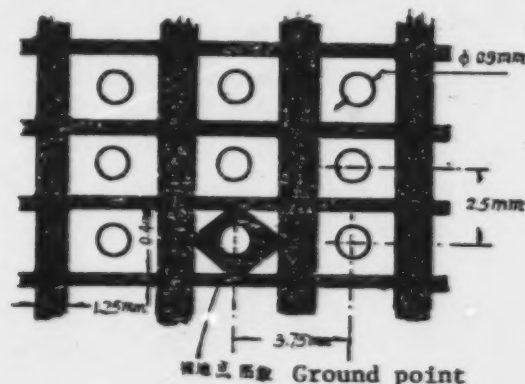


Figure 3.

Electrical characteristics: $C = 80-90$ pF/M (capacitance per unit length); $L = 0.6-0.8$ μ F/M (inductance per unit length); $Z_0 = 80-90$ ohms (characteristic impedance); $T_d = 0.075-0.08$ ns/cm (no-load printed circuit delay); $R_d = 0.02$ ohms/cm (DC resistance of signal lines).

3. Printed Circuit Board Design Satisfies High-Speed Transmission Electrical Requirements

(1) Selection of Order of Layers, Materials, Signal Line Width, Dielectric Thickness, Ground Network Layout in Terms of Requirement for 90-Ohm Impedance Matching

The characteristic impedance Z_0 of one transmission line is

$$Z_0 = \sqrt{\frac{L}{C}} \quad \begin{array}{l} L \text{---inductance per unit length} \\ C \text{---capacitance per unit length} \end{array}$$

where L is the inductance per unit length and C the capacitance per unit length. When a planar microstrip transmission line is produced on a PC board, the characteristic impedance is approximately expressed by the following equation (see Figure 2(c)):

$$Z_0 = \frac{87}{\sqrt{\epsilon + 1.41}} \ln \left(\frac{5.98 h}{0.8 w + t} \right)$$

The equation is relatively accurate when $\frac{w}{h} \leq 1.25$. We chose glass-reinforced epoxy resin as the board material. Its dielectric constant is $\epsilon \approx 5.4$; and $w = 0.2$ mm, $h = 0.6$ mm, $t = 0.05$ mm;

$$Z_0 = \frac{87}{\sqrt{5.4 + 1.41}} \ln \left(\frac{5.98 \times 0.6}{0.8 \times 0.2 + 0.05} \right) \approx 94.3 \Omega$$

The signal lines in the interior of the printed boards are laminated in, as shown in Figure 2(d). Tests indicate that $Z_0 \approx 80-90$ ohms. On layers 2 and 7 the signal lines must be spaced farther from the ground by increasing the thickness of the semihardened adhesive film by 0.1 mm; accordingly the resistance of these two layers is greater than that of the signal lines in layers 3 and 6, and the widths of the signal lines in these two layers should be increased so that their characteristic impedances will be the same as those in the inner layers.

(2) Decreasing Interference Between Lines

In the sequence of layers, the four layers with signal lines in them are divided into two groups by the ground and power supply networks; in each group, one level carries the crosswise lines and the other the lengthwise lines, so as to decrease mutual interference. In the case of parallel signal lines within a PC board, there are three situations: ① the crosswise signal lines within the layer are laid out with one in each 2.5 mm coordinate space, so that the distance between signal lines is 2.5 mm and the mutual interference is low; ② the vertical lines in a layer are arranged with two in each 3.75 mm space so that the smallest distance between lines is 1.25 mm; ③ signal lines in two neighboring layers are generally staggered, producing very low interference. The few overlapping parallel lines are close together (0.1 mm), and accordingly in the automatic wiring layout process it is specified that overlapping parallel lines in adjoining layers must be less than 1 cm long.

(3) Decreasing the Length of Connecting Wires in the Computer and Decreasing Line Delay

Where component layout permits, a small coordinate grid is used, decreasing it from the original 3 mm spacing to 2.5 mm. In this way, with an equivalent number of coordinate spaces, the length of connecting lines between two points is decreased by a sixth. In addition, automatic wiring layout is used for optimal selection of the shortest path between two points, and double 72-line PC cards are used, with direct connections between the signal lines and card connection paths instead of the previous practice of running the signal lines in a circuitous path and concentrating them in a single central plug, thus increasing wiring length.

(4) Use of Multilayer PC Boards in Order To Match the Impedances of Cards and Boards, and Use of a Complete Grounding System

The multilayer PC boards measure $300 \times 235 \text{ mm}^2$. They have the same sequence of layers and patterns as the cards, and their characteristic impedance is 90 ohms. They can hold 12 PC cards, and signal lines between cards and boards are impedance matched so that there is no wave reflection. The ground network within the cards passes down both sides and is connected to the metal spring strips in the guides and thence to the frame. In addition, the PC card has 36 ground lines connected to the internal ground of the PC board. In this way a complete grounding system is provided from card to board to

frame, and the layers carrying the signal lines are separated by the grounding network, which decreases crosstalk. The use of PC boards also gives the following advantages: their production can use automated wiring layout, numerically controlled [NC] scanning photographs, NC hole drilling, and NC card testing. The printed circuit boards are uniform, which is convenient for soldering and repair; and the board units can be assembled separately, thus overcoming the earlier deficiency of board production that only a few workers could be involved with each board and the time required was long.

4. PC Board Design Suited for Installation of the Chosen Components and Devices

The integrated circuits chosen for the 757 machine are of the DIP type and the connectors are 72-line card connectors; the choice of multilayer board characteristics must be suited to these features; ① The coordinate spacing is chosen as 2.5 mm in the x direction and 3.75 mm in the y direction, which matches the spacing of the pins within each line on a DIP package and the distance between the two lines. ② The hole diameter, ϕ , chosen is 0.9 mm, which is suited to the pin cross section of the DIP packages, and which increases the extra installation room when the size of the holes is decreased by metallization (see Figure 4).

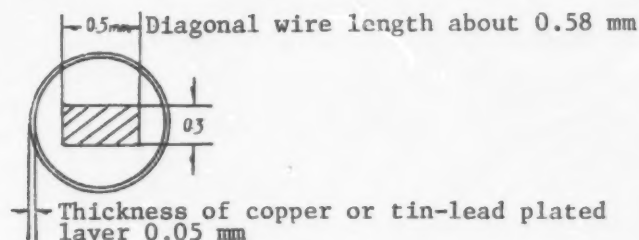


Figure 4.

The pins become thicker when tinned, but because surface tension causes a minimal increase in the length of diagonal lines, this can be ignored. ③ The board thickness was chosen as 2.3 ± 0.15 mm, primarily in terms of the requirements regarding electrical characteristics. The characteristic impedance is 90 ohms, the corresponding signal lines must be separated from the ground layer by a dielectric layer 0.6 mm thick; after the board is laminated the thickness is 2.3 mm. The card connector was chosen afterward. With a board thickness of 2.3 mm and with package pins 3.5 mm long, the pins protrude through the board about 1.2 mm after installation, which makes for ease in soldering. ④ The width of the signal lines was chosen as 0.2-0.25 mm in terms of a characteristic impedance of 90 ohms; of the factors influencing the characteristic impedance, the dielectric constant of the board material and the thickness of the copper film had already been chosen, and thus the only factors that could be adjusted were the thickness of the dielectric material and the width of the lines. Increasing the board thickness in order to increase the width of the lines would cause problems in hole drilling, and if the thickness was increased and the lines made extremely fine, the acceptance

rate would be low; this is why a width of 0.2-0.25 mm was chosen. ⑤ The choice of ground network dimensions was constrained by the lattice spacing and hole diameters. Under these constraints, the largest permissible ground holes were chosen in order to increase the production acceptance rate and to decrease short circuits between plated-through holes and the ground network.

5. Board Design Suited to Production of Many Varieties in Small Quantities

In the laminated layers of the board, the solder areas on both sides, the IC package areas, and the power supply and ground networks have the same pattern on each of the eight layers for the entire machine, so that for different card models it is only necessary to change the signal line layers, and in production the photograph scanning has to be performed only once. A general purpose standardized zone was used to drill the holes for the IC pins, the plug connection holes and inspection holes. On different board models, the adaptor junction holes between layers were different, but the data for drilling them are provided by automatic wiring layout.

III. Process Design for Multilayer Board Production

1. Multilayer Board Production Process

The process flowchart is shown in Figure 5.

2. Advantages of the Process

(1) Advantages of the dry photoresist reverse plating method; ① It eliminates the possibility of paint peeling off wires and pipelines. ② The board surface quality is high, with no exposure of the reinforcing cloth weave. ③ It increases the reliability of the plated-through holes. Because the current is uniform when plating the entire board, the metal film in the walls of the holes is of uniform thickness. In addition, the board has no lacquer film, so that the problem of contamination of the holes making metallization difficult, is eliminated. ④ The use of a lead-tin alloy replacing dip metallization decreases production costs, and soldering is more reliable. This also decreases warping of the board by heat during the dipping process.

(2) Advantages of Numerical Control of Photograph Scanning, Hole Drilling, and Board Testing. ① It eliminates manual wiring and drawing of the original pattern, the automatic wiring cycle for the computer is short, the quality is high, and the percentage of completed connections is high. ② Direct numerical control of scanning of negatives gives a high positioning accuracy. The resulting negative has good black and white contrast and uniformity of pattern. ③ Numerically controlled hole drilling is done with high precision, quality is high, and labor is saved. ④ NC testing of boards makes it possible to determine correctly whether the wiring of a multilayer board has short circuits and broken circuits. In the past, with manual testing, it was very hard to detect short circuits between lines. The testing is rapid and assures that the boards are correct.

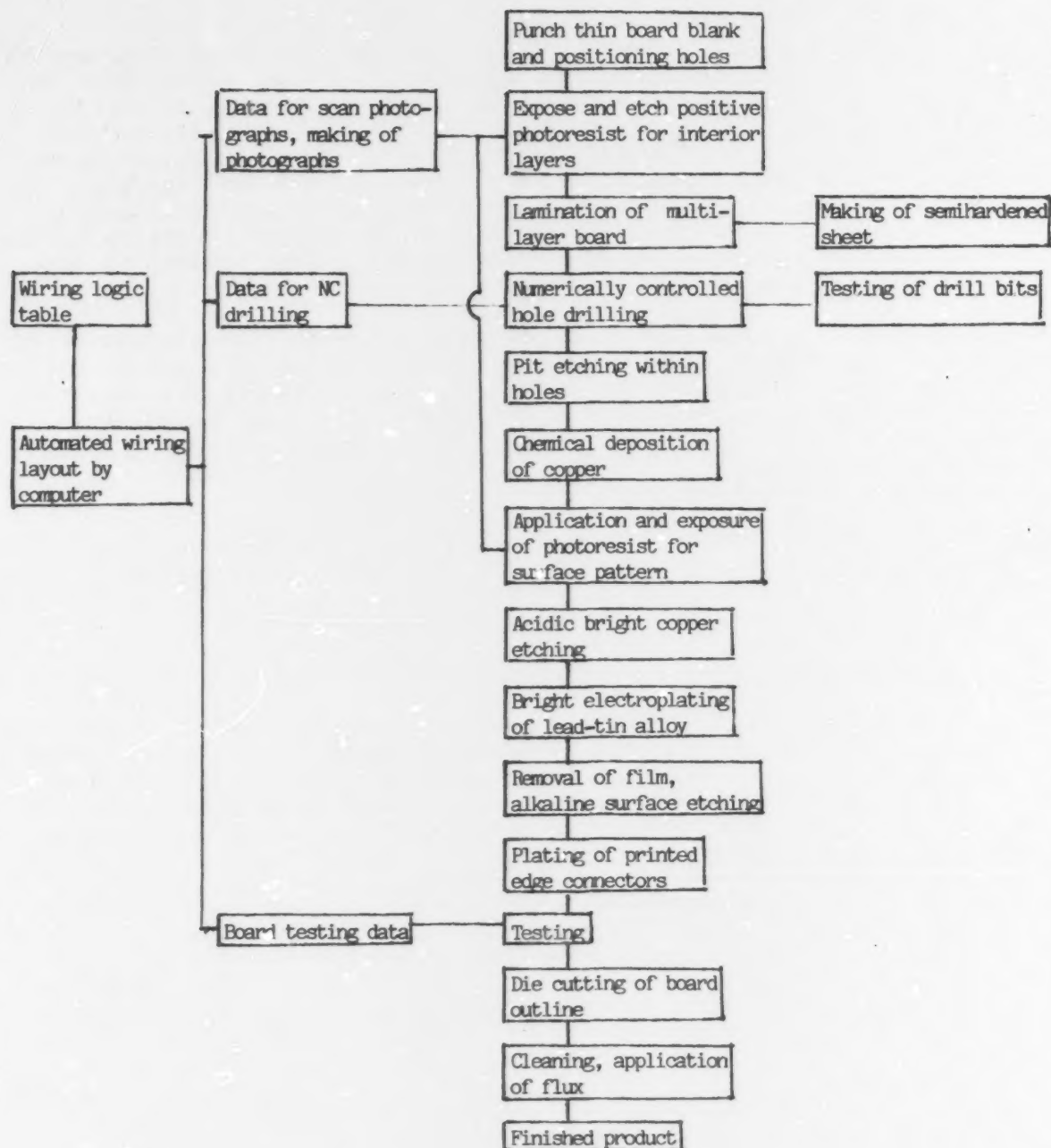


Figure 5.

(3) Advantages of Using System Positioning: ① The positioning holes punched in the thin film are used continually up to the die cutting stage. There is no need to change positioning holes in the middle, so that precision is high and effort is saved. ② When punching the positioning holes in the pattern, the pattern is first held immobile under pressure, then processed, which prevents it from bowing when the holes are punched, to avoid incorrect hole spacing. A pattern positioning device is used for the outer board, so that positioning accuracy is high and the pattern is not damaged. ③ Die cutting of the multilayer board assures that the dimensions of the 72-line edge connectors and the outline will be accurate.

(4) Advantages of Using Rolled-on Positive Photoresist To Produce Inner Layer Patterns: ① High line accuracy and production efficiency. ② Direct use of photographed positive pattern to scan obviates the necessity of again producing a negative, which saves on film. ③ During etching there is no excess emulsion, so that the surface does not need to be cleared, which saves machining and maintains quality. ④ Once the layer is applied the board can be stored for half a year and exposed at any time.

(5) Advantages of the Use of Semihardened Adhesive Sheet and Roughening of Interior Layer Patterns: ① The sheet has longer storage life than the anhydride form. ② It has good resistance to solder dipping. ③ It eliminates microseparations in the inner layers and increases board reliability.

3. Reliability Analysis and Control of Multilayer Printing

The reliability of multilayer boards involves board shape, material, lamination pressure, hole drilling, chemical deposition of copper, copper plating, positioning, and the like. In the past, we used concave etching; we chose a non-resin board material to eliminate microseparations during pressure lamination of the boards; we used a hard alloy drill head to drill the holes, a barium activation process for the adhesive, and acidic bright copper plating, all of which have yielded good results. The 757 machine's multilayer boards also pose the problem of the effect which soldering of the package pin holes and die forming of the external outline have on metallization. In order to assure the reliability of the boards, in addition to already existing measures, we have taken the following improvement steps, as well as performing experiments on the effect of hole drilling and soldering and blockage on quality with reference to metallization.

The reverse plating method was used instead of process wiring. This produces uniform plating thickness within the holes, and the process does not require flowing on of lacquer, which eliminates plugging of holes.

(2) Before laminating, the copper layer for the inner layers is roughened by copper chloride etching, and the contact pads for the ground network are diamond shaped, which increases adherence between layers and eliminates microseparation when holes are drilled.

(3) A glass-reinforced epoxy board is used as a pad when drilling the holes, rather than a phenolic board or epoxy-phenolic board in order to prevent

contamination during concave etching after the holes are drilled and before metallization.

(4) The resistance of the wiring holes is tested before and after the package pins are inserted in the holes and soldered, and again after the routine tests. Repeated testing during multiyear use of the machine has shown that the resistance of the holes does not change.

(5) The pin hole resistances are checked before and after die cutting of the board outline; the value is unchanged and there is no layer separation in the boards.

Large-scale production of the 757 machine's multilayer boards and multiyear operation of the entire machine have shown a high acceptance rate and high reliability. In the future, further research will be conducted on how to make better use of computer aided design and to produce high-density multilayer boards suited to large-scale integration [LSI] circuit components.

8480/9365

CSO: 4008/249

THE ARCHITECTURE, PRINCIPLES AND DESIGN OF THE 757 VECTOR COMPUTER'S ARITHMETIC UNIT

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTERS AND DEVELOPMENT] in Chinese
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[Text] Abstract: This paper introduces the arithmetic unit of the 757 vector machine with respect to its basic architecture, function and characteristics; skip station type and successive station type operational pipeline control under microinstruction and macroinstruction two levels of control methods; and some existing problems concerning a few major calculation methods and design.

I. Preface

The 757 vector computer is a monoprocessor with a pipeline architecture. A computer system made up of a primary (processor) and secondary (peripheral computer) computer groups, undertakes the task of the host processor, implementing primarily vector (arrays and byte strings) computation while at the same time giving appropriate consideration to scalar operational tasks.

In hardware design, the three basic technical measures, namely, time overlap, resource duplication, and resource sharing, are used to exploit fully the parallel nature of the monoprocessor system and to improve machine operating speed and system use efficiency. Improving the system use efficiency is the top priority performance target of the system design.

The central processing unit implements internally the parallel flow of the instruction level to the first order, which is divided into instruction control, memory control, operational control and the arithmetic unit, the four major functional units. The job of each unit is to complete its own fixed operation through overlapping in time.

In order to exploit fully this parallel nature and to improve the processing speed, non-arithmetic instructions are executed by instruction control while the arithmetic unit executes only operational instructions. In this way, as much as 50-60 percent of the execution time of such instructions as branch, index, GET, and loop, etc. are absorbed by the execution time of the arithmetic instructions, without affecting the output of floating point operations results and thus improving the processing speed of the host machine.

In order to reduce the possible internal collisions which may occur with arithmetic instructions addressing the internal storage, a configuration of 12 addressable multiple accumulators is used to store operands and intermediate results. The multiple cross memory technology adopted resolved conflicts in addressing internal storage and maintained a balance between busy and idle for each entity so that internal storage and the central processing unit speed could be coordinated. The design of multiple accumulators, multiple buffers and multiple parallel memories are manifestations of resource redundancy and thus clearly improve the frequency band of each functional unit.

In order to adapt the system to the demands of operational speed, the arithmetic unit uses a pipeline single arithmetic unit configuration. This type of configuration is less costly, its facility efficiency is high, and at the same time it simplifies the allocation and control of the instruction flow and data flow to the operational and control units.

The arithmetic unit deals mainly with the operation control component, and does not communicate directly with the instruction control and memory control. It carries out arithmetic operations and data editing and control. In the arithmetic unit the vector and scalar operational algorithms of the same instruction are the same with the only difference being that in execution there may be some discrepancy in the depth of the parallel overlap and operational control.

There are altogether 77 operational-type instructions in 15 classes, which, except for the prefetch instructions carried out by operational control, are executed by the arithmetic unit.

The design of the arithmetic unit was carried out based around the three targets, which are advanced nature, high speed, and reliability. In design, the characteristic functional flexibility of the ECL modules as the basic logic unit circuits is fully employed; the "wired-OR" technology and the positive/negative alternating logic technology are widely used, saving components, reducing the number of interconnected logic gates, and thus improving the speed. Such high speed algorithms as multiplace serial-parallel multiplication, iterative division, one beat polarization, normalized addition, and one beat shift are used. A detector system is set up to include auditing, double calculation, and diagnosis, thus, improving the stability of the system.

II. Design and Characteristics of the Pipeline Single Arithmetic Unit

As everyone knows, the pipeline technology divides a repetitive sequential process into a certain number of sub-processes and carries out each process simultaneously with other sub-processes at a dedicated functional station, thus implementing overlapping parallels in time. Clearly, after selecting the operational method, the important task of the designers was how to divide a repetitive sequential process, i.e., the processing instruction process, into a certain number of individual operational steps for execution. We will explain this in the example of floating point addition. Normally, addition is divided into six operational steps: finding the difference of orders, saving the larger value, symmetric value shift, summing the mantissa, standardizing the result, rounding off, and overflow processing.

Clearly, under the pipeline work mode, relying on the algorithm to divide up the operational steps demands the setting up of a dedicated function network to implement each operation. However, are these functionally different networks independently established stations, an amalgamation into one station of a certain number of dedicated networks, or is one functional network separated into two stations? This is another important question which the design of the pipeline operational component must resolve, and it is also a problem of how to divide the functional stations.

The principle of dividing the functional stations is that the execution time of the logic networks which make up the functional stations is generally approximately the same or equal. This is because only when the execution time of the functional stations is the same can the functions in the pipeline always be in the busy state so that the pipeline can complete its tasks at the highest rate of speed. Actually, the machine's clock frequency which also means that the execution time of the functional stations was decided to be equivalent to one clock cycle early in the system design.

We know that the length of the execution times of the six operational steps in addition are not the same and that there are great differences, therefore the stations could not be divided according to their natural operational steps. This meant that after the processes had been divided, they all had to be analyzed comprehensively and then synthesized.

Figure 1 illustrates the basic architectural outline of the 757 vector computer arithmetic unit. It is made up of a five-station structure. It divides the six operational steps of the addition process among four stations, i.e., difference in value codes [jiama xiangjiang [7132 4316 4161 8096]] (finding the difference in value) and saving the larger value are the first station; symmetric value shift is the second station, mantissa preload and rounding off are the third station, and standardizing the result and overflow processing are the fourth station. The result is then transmitted into the fifth station.

Although the arithmetic unit is constructed of five stations, only four stations have logical functions; the fifth station does not execute logic operation, but is only an auxiliary buffer station.

If we set aside the engineering implementation, we see that the results of the operations of standardization, shift, compressing and revising the value codes carried out by the fourth station can be sent directly to operational control L, G, and H and need not go through the fifth station. However, from the perspective of engineering implementation, this is impossible to realize for the following reasons: (1) operational control and the arithmetic unit together use six boards, the distance between them is too great, and the circuits too long so that the added burden is very heavy and there are many allocating series gates [fentuichuanmen [0433 2236 0025 7024]]; (2) the operations carried out by the fourth station are very complex and require the occupation of more logic series; (3) to send correct results, the operational results should be checked and it is impossible to implement these operations within one beat. For this reason, the E register, called the fifth station,

was created, to store temporarily the operational results of the fourth station, and buffer the tight temporal relationship between the interfaces. Adding the fifth station, generally speaking, will not influence the efficiency of operation.

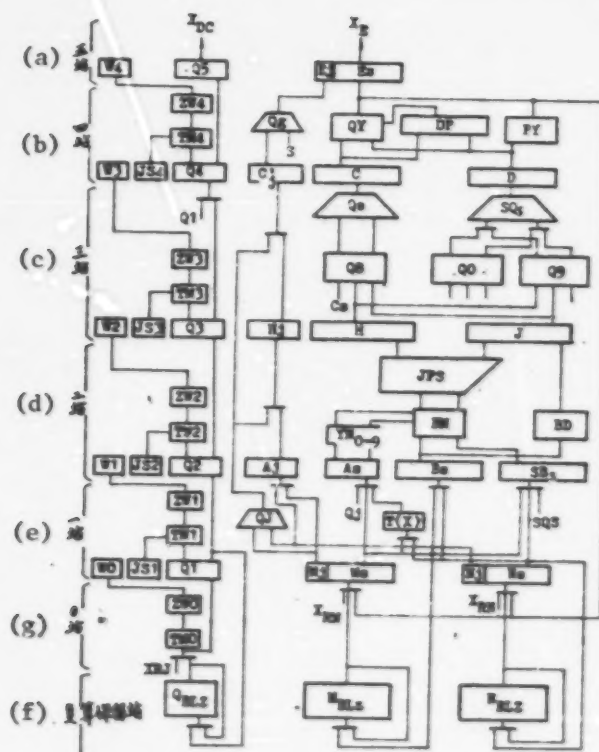


Figure 1.

Key:

- a. station 5
- b. station 4
- c. station 3
- d. station 2
- e. station 1
- g. station 0
- f. double calculation reserve station

Each station is made up of some functionally different logic networks, such as the Qj, JFS, Qs, Qg networks. They each carry out a specially designated operational procedure of the pipeline and the execution time of each procedure takes about one beat. Registers are used as separators between stations, such as the M, N, B, H, J, C, D registers. The operational results of the previous

station are stored in the register of the next station which act as the operational number of the next station's operations. It is thus easy to see that the length of each register depends on the word length of the result from the previous station.

Looking from the angle of control, there is a 0 station preceding the first station. It is made up of two elements: one is the message sent by the Czd control station that it receives and combines to produce the conditions for setting up microinstructions and discriminates in advance the operations to be executed by the instruction; the other part carries out preselect control of commands and operations sent in the double calculation reserve station.

III. Skip Station Type and Station-by-Station Type Operational Pipeline and Their Control

Operational instructions are divided generally into:

1. Standard arithmetic operational instruction: although its functions are simple, the algorithm is very complex. It determines the basic structure and processing speed of the arithmetic unit. Implementing this instruction uses all five stations of the arithmetic unit and is called the station-by-station type operational pipeline.
2. Basic arithmetic operational function instructions for exponents, root extraction, and logarithms, such as separating an integer to exponents, which are implemented by a combination of software and hardware.
3. Pseudo-arithmetic operational instructions which perform editing operations, such as compare, shift, and logic instructions.

The latter two types of instruction algorithms are simple and can be implemented by stations 1, 4, and 5. Since they skip over stations 2 and 3 they are referred to as the skip station type operational pipeline.

In parallel tasks which overlap a great deal, how is the instruction sequence of skip station and station-by-station instructions controlled? Clearly, the control of this pipeline process is very complex and if the processing is not appropriate it can very easily lead to conflicts between devices or instruction clashes which upset the orderly process of command execution.

The arithmetic unit employs a command response control mode to control the instruction flow.

The basic idea is: the instruction about to enter the arithmetic unit is responsible for issuing a command permitting the instruction which is waiting next in sequence in the operational control execution station to enter the arithmetic unit. This command clearly stipulates which class of instruction in the execution station and when it may enter the arithmetic unit.

After the successor instruction receives a command coinciding with the conditions, it cannot directly be pushed because the operational control still

must decide whether or not the successor instruction operational operand readiness is in order. If the operand is ready, then in the next beat the successor instruction can be pushed into the arithmetic unit, otherwise, a break chain [duanlian [2451 6969]] situation occurs.

Normally, break chain refers to an interrupt in the instruction flow or to a number not yet ready which puts the arithmetic unit into the idle state. We have set up four enable to enter commands.

1. Enable primitive [yunben [0336 2609]] command

Only the vector command has the right to issue this command which is used for scheduling between components. The enable primitive command has a self-maintenance function so that when break chain occurs, it maintains its original state.

2. Enable double word high order partial entry command

To save on equipment, the double word operation uses single word equipment, thus the high order and low order enter the arithmetic unit separately. After the low order has entered the arithmetic unit, it issues a command permitting the high order to enter. The dual shift instruction permits a break chain between the high and low order operations and at this time allows the dual high command to have a self-maintaining function until after the high order enters the arithmetic unit, at which time it is released. The low order operational number waits in D, until the high order part arrives, and then one shift is carried out together.

Dual addition type instructions do not permit a break chain between high and low order, otherwise, operational chaos would occur in the arithmetic unit that cannot be checked. For this reason, after the high and low order are established to be all in order, then an "all orders arrived" ["shudaogi" [2422 0451 7871]] condition is issued.

3. Enable to add command

Only addition and divide commands can issue enable to add commands, and only addition, multiplication and divide commands which are ready in the execution station can accept and execute enable to add commands.

4. Enable new command

Its rank is high and its functions include: (1) It is the arithmetic unit start command, and in the initialization stage it is used to schedule the instruction flow of the first instruction to enter the arithmetic unit; (2) during break chain, it is used to restore the instruction flow; (3) after an enable new command is issued, any instruction in the execution station must enter the arithmetic unit in the next beat as long as its numbers are in order.

This type of command mode control of the overlapping of the instruction flow is effective and it works. They systematically schedule the instruction flow

in the arithmetic unit sometimes in serial and sometimes in parallel and thus exploit the feature of a lesser amount of equipment in a single arithmetic unit but not a lower rate of pipeline efficiency.

IV. Algorithm

1. Floating-point addition algorithm

This operation is carried out in five beats and is characterized by implementation of polarization and standardized operations within one beat. For example, $(A) + (B) \rightarrow C$, in which $A(a_0, a_1, \dots, a_n)$, $B(b_0, b_1, \dots, b_n)$, $C(c_0, c_1, \dots, c_n)$ are all vectors. Actually, the arithmetic unit carries out a series of additions, $a_0 + b_0 \rightarrow c_0$, $a_1 + b_1 \rightarrow c_1$, $\dots$, $a_n + b_n \rightarrow c_n$. The unifunctional pipeline [dantiao [0830 2742]] addition flow is as below:

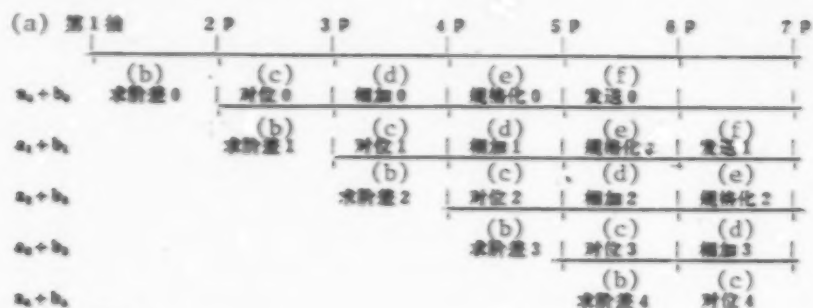
First beat to subtract exponents and save the large value: the instruction receives Q_1 , a_0 and b_0 receive M and N respectively, and through Q_j to find $\Delta j = M_j - N_j$;

The second beat polarization: if Δj is positive, M is the large number, M_s sends to S_B s, and N_s sends to B_s ; if Δj is negative, N is the large number, N_s sends to S_B s, and M_s sends to B_s ; B_s shifts right $|\Delta j|$ places through JFS .

The third beat mantissa addition: S_B s sends to J , the number shifted through JFS sends to H , H , and J through Q_s .

The fourth beat standardization: the sum is entered in C , discriminating standardized places is used to turn on the QY network's shift gate and through Q_g revise the resultant exponent.

The fifth beat transmits: the result which has been standardized is stored in E so it can be transmitted. Figure 2 illustrates the addition pipeline's overlapping processing time.



Key:

- a. first beat
- b. find difference
- c. polarize [duiwei [1417 0143]]
- d. add
- e. standardize
- f. send

Figure 2. Addition pipeline overlap

2. Multiplication algorithm

To improve operational speed, a multidigit rapid multiplication algorithm which still uses the idea of addition-shift loop for multiplication, was used. The multiplication execution process can be viewed as an addition process of a series of addends.

As concerns the application of the SSI integrated circuit to make up a large scale rapid system, the multidigit string parallel multiplication is still rather advanced.

The multiplication unit design developed mainly along three lines:

(1) Reducing the number of addends: this computer uses multiplication by groups based on three, it consolidates three multiplicands of a certain multiple which were to have been processed and reduces them to one addend. For example, 56×56 is divided into two processes, the first carries out 56×29 iteratively and the second carries out 56×27 iteratively. Then add the difference of the two products of places to obtain the complete answer.

(2) Formation of the accelerated addends: the right 29 places (or left 27 places) of the multiplier send in the encoder to be encoded, using gate control the multiplicand multiple forms the circuit BM so that BM simultaneously outputs 10 group (or 9 group) addends. The multiple gating network structure is simple and designing a rapid encoding circuit is the key to accelerating the formation of the addends.

(3) Accelerating summation of addends: we designed a four level structure adding tree permitting the addition of 9 addends made up of memory carry full adders. Its word length is 84 bits and each bit is made up of 7 full adders. Using positive negative alternating logic design technology, partial sums and carries have at most seven level delays, addition sums summation is still relatively fast. Figure 3 illustrates the four level structure addition tree.

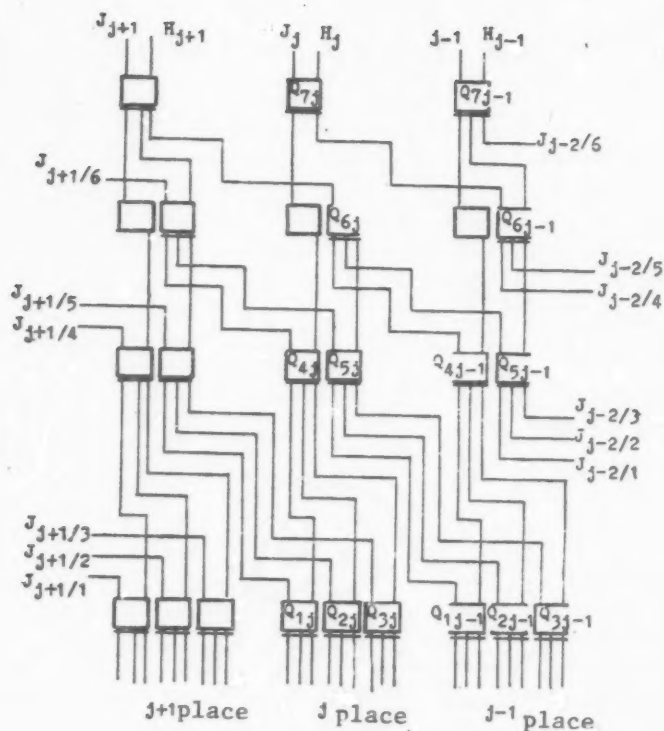


Figure 3 Addition tree

The multiplication formula derivation result is:

$$\begin{aligned} Cs &= As * Bs \\ &= Csf + Css \\ &= Csf + Css_2 + 2^{-27}Css_1 \end{aligned}$$

in which $Csf = Asf \forall Bsf$ is the product symbol; $Css = Css_2 + 2^{-27}Css_1$ is the complete multiple; Css_1 is the first product; Css_2 is the second product.

On the basis of the above formula, the decoding formula is:

$$-A_1 + \frac{1}{2}A_2 + \frac{1}{2^2}A_3 + \frac{1}{2^2}A_4$$

It is easy to see that it will translate 16 states, and eight operations, i.e., $\pm Bss$, $\pm \frac{1}{2}Bss$, $\pm \frac{1}{4}Bss$, and $\pm \frac{3}{4}Bss$. As soon as multiplication begins, the $3/4$ times multiplicand should be formed in preparation for decoding the gating. The multiplication process is generally as follows:

1. Finding Css_1 :

$t = 0$, multiplication instruction enters $Q^{(1)}$, multiplier and multiplicand enter M and N respectively;

$t = 1$, Ns sends into Bs, SQs implements $\frac{1}{4}Ns + \frac{1}{2}Ns$ addition and sends into SBs. MS right 29 digit sends into As, 10 group encoder decodes separately, each group interpretation gates one group multiplicand multiple forms a circuit, takes the addition sum obtained in order of difference of 3 places, obtaining two numbers, the partial sum of Css_1 and a carry:

$t = 2$, the above two numbers are stored in H and J;

$t = 3$, find $Css_1 = H + J$, save in C and D.

2. Finding Css_2 :

Css_2 begins execution from $t = 2$ and is carried out overlapping with Css_1 . At this time Ms left 27 digits send into As and the second decoding, it is the same operation as in $t = 1$, is carried out. $t = 3$ saves the partial sum obtained and advanced to store in H and J.

3. Finding Css :

When $t = 3$, Css_1 is in C and D, and Css_2 is in H and J; $t = 4$, Css is found through Qs and SOs, Css is a double word product and the word length is truncated in line with the demands of the instruction; $t = 5$, Css is entered into Cs and standardization is carried out; $t = 6$, the result is sent to E and the next pulse is emitted.

Figure 4 shows the overlapping process times of the multiplication instruction. From the diagram it can be seen that general multiplication takes only 5-6 beats. When not interrelated, it takes only 2 beats to produce a result. When the pipeline is stable and the equipment is not idle, the utilization rate is at its highest.

V. Discussion of Some Questions Remaining in the Arithmetic Unit Design

Software debugging and test problems over the past two years have demonstrated that the design of the 757 vector computer's arithmetic unit is successful and its primary functions reach or surpass the demands of the anticipated technical indicators. Under high efficiency conditions, the fixed speed of the arithmetic unit can achieve 8.2 million floating point additions per second or 4.1 million floating point multiplications, or 10.25 [1.025?] million floating point divisions. In the design process, to the extent possible, many advanced design techniques and high speed algorithms were used and much beneficial experience was gained, but there are still some inadequacies. The aim of this study is to learn and to provide reference points for improving and developing similar vector computers.

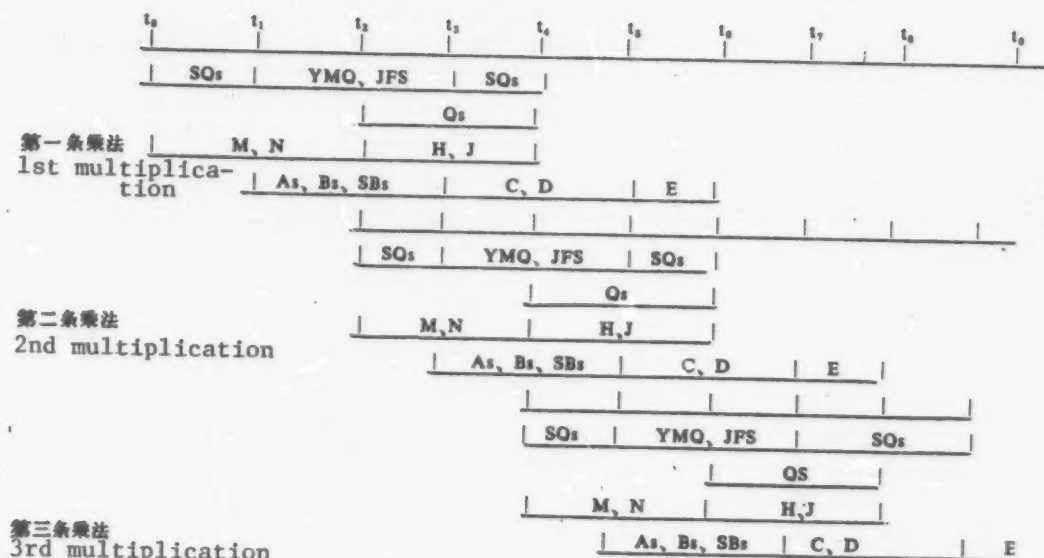


Figure 4 Diagram of time overlap in multiplication pipeline

1. Questions of introducing partial operations in the parallel structure of the pipeline

Previous arithmetic unit designs used the concept of shifting to partial operations customary for earlier traditional computers for normalization and shift operations exceeding 8 bits. Local operations take place mainly in the fourth station. When executing a process that shifts to local state, the pipeline encounters a serious obstacle. At this time, each pipeline function station behind the "local point" rapidly becomes empty and is in the idle state; each pipeline function station in front of the "local point" becomes filled consecutively, but there is no way for the flow to get through and most are in the waiting state. At this time, besides the "local points" being in a very busy state, the rest of the pipeline function stations are "asleep" and only can be awakened after the partial operations are concluded and control is returned to the center. It is obvious that local operations not only clearly lower the operational efficiency of the pipeline, but also make control very complex. Since local conditions both lock up the first, second, and third stations ahead of the "local point" and lock up station 0, over half of the arithmetic unit and the operational parts of the execution stations are nearly locked up, its burden is very heavy. This not only increases the drive levels added in the control link by at least two to three, but also radiates several hundred leads in all directions from the "local point" which is very hard to accomplish in high speed projects.

Through analysis and research we learned that we cannot apply the local control concept in the pipeline structure mechanically. The problem that local

control creates is not a general "bottleneck", but a basic problem of creating an "appetite" that's too small and cannot process data at high speed. Thus we have revised the design to make normalization and shift control one beat operations so that the flow would be unobstructed and under stable conditions achieve a maximum operation rate of one output task per beat.

2. Concerning station-jump operational pipeline

Arithmetic unit adopted station-jump and sequential-station type operational pipeline modes for processing of instructions. Viewed narrowly, this type of set up can make the non-four fundamental operations of arithmetic instruction flow jump the second and third stations and go directly to the fourth station as if to accelerate the flow process and improve flow efficiency.

In fact, this is a false impression. This is because operational efficiency is not decided by the number of pipeline stations, but mainly by whether or not enough tasks can be provided to fill the pipeline, reduce idle and waiting time, and strive to be able to output a result during each cycle.

Using the instruction sequence formed by instructions of these two kinds of flow makes scheduling and control very complex. It creates problems in the design of operational control components, adds many devices and also increases the number of levels in the logic chain. If only the sequential station flow mode is adopted, enable commands could be greatly simplified and control be made much simpler, yet flow efficiency would not decline.

3. Concerning micro-instruction control mode

The arithmetic unit adopts micro-instruction and macro-instruction control. Macro-instruction control is normal combination logic control and is control of combined implementation of a beat decoding and the conditions it generates. In the arithmetic unit, this analytical and synthetic control process generally requires only 6-8 logic levels.

Micro-instruction control predicts the conditions created by an instructional operational step one beat in advance, discriminates the combination of these conditions in advance and stores them for use by control in the next beat. Its superiority is that it moderates the shortness of time of the long chain control group used by that beat and shifts the pressure to the logic link in the previous level letting the previous beat absorb it and lighten the pressure on the time used by that beat. The logic designers frequently adopt this type of design technique to compress or reduce the number of long chain logic levels. Under appropriate circumstances, using a smaller number still can be effective.

In short chain control design, the group conditions formed by a beat can be controlled in a timely fashion thus it is not necessary to adopt the prediction and prejudgement techniques in the long chain. Advancing prejudgement is not only very complex, but also very expensive. That is to say, from the angle of control, microinstruction control mode does not have any superior characteristics and advantages. As far as trying it out in other aspects, the advantages and disadvantages will have to be weighed.

4. Where are the arithmetic unit's "bottlenecks"?

Analysis and practice shows that the triple number adder SQs is an arithmetic unit "bottleneck". SQs is mainly used for multiplication and division operations seeking triple numbers. When the multiplication/division pipeline is operating, it is constantly in the busiest state but some function networks are nearly in a semi-idle waiting state, equipment frequency band loses its balance which affects operating efficiency. If in improving the model we are willing to make some outlays, add other equipment and readjust the operating process the efficiency clearly might be higher.

The process of developing the 757 vector computer arithmetic unit was tortuous and uneven. Its successful development was the result of collective effort and is the crystallization of the wisdom of the masses. In the early stages of the arithmetic unit logic design (July, 1975-September, 1977) Comrades Wang Peixian [3769 0012 7359], Tian Gongxing [3944 0361 5281], Fu Chaoyuan [0102 2600 0337], Li Xiuying [2621 4423 5391], Chen Dingxing [7115 1353 5281], Zhang Fujiang [1728 4395 3068], Xu Jun [1776 3182], Xu Kunming [1776 2492 2494] and Man Yunxia [3341 6663 7209] participated in part of the design. In the later logic design, project design, linking and debugging test calculations and reliability testing stages, Comrades Wang Zanming [3769 6363 2494], Li Minfu [2621 3046 3940], Li Xiuying, Li Ceming [2621 4595 3046], Chen Dingxing, Yang Yucheng [2799 7183 2052], Chen Hongan [7115 7703 1344], Hou Qi [0186 0796], Xu Kunming, Zeng Fulin [2582 0102 2651], and Liao Qingyu [1675 7237 5940] also participated in the work.

8226/12712

CSO: 4008/364

ON SOME PROBLEMS IN THE DESIGN AND DEBUGGING OF THE INSTRUCTION CONTROL PULSE SYSTEM OF THE 757 COMPUTER

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese No 8, 1984 pp 1-7

[Article by Song Chengjiu [1345 2052 0036] of the Beijing 9th Research Institute, Wang Zongpei [3769 1350 3805] and Teng Chunming [3326 2504 2494] of the Institute of Computing Technology, Chinese Academy of Sciences]

[Text] I. PROBLEMS

The pulse cycle, logic chain length, and transmission overmeasure in the pulse synchronous system of a large scale computer should satisfy the following relations:

$$T = n \cdot t_{pd} + l \cdot t_{dl} + \Delta$$

in which: n is the number of logic gates through which the signal passes in a given cycle, or called the number of levels for short.

t_{pd} is the time required for the signal to pass through one gate.

l is the length of the transmission line through which the signal passes in a logic chain, or called line length for short.

t_{dl} is the time necessary for the signal to pass through one unit of line length.

$n \cdot t_{pd} + l \cdot t_{dl}$ is the length of the logic chain.

Δ is the transmission overmeasure, or called overmeasure for short.

This paper was received in Feb 1984.

A certain overmeasure is provided to overcome the lack of uniformity created by a large number of components in the system, many routes, scattering and drift of component parameters, unevenness of routing lengths, and changes in pulse frequency and at the same time it is also to avoid unexpected situations which occur in the design and debugging of large scale computer pulse systems.

Table 1

Item	109 B	111	013	757 instr. ctrl*	MU-5	ILLIAC-III
Cycle	330 ns	330 ns	167 ns	100 ns	50 ns	67 ns
Number of design levels	6	10	25	17.5		
Number of actual levels	6	10	27	17.5	8	
Designed level delay (with negative load)	40 ns	25 ns	5 ns	4 ns		
Actual level delay (with negative load)	30 ns	20 ns	3.5 ns	3.5 ns		
Actual level delay (with negative load and route)					4 ns	1.5-5.5 ns av. 2.5 ns
Routing length	5 m single line	5 m single line	5 m twisted pair line	4 m twisted pair line		
Designed delay time	255 ns	265 ns	165 ns	90 ns		
Actual delay time	195 ns	215 ns	134.5 ns	<100 ns		
Designed overmeasure	23%	20%	17.5%	18%		
Actual overmeasure	41%	35%	20%	<10%	20-30%	25%

*Refers to 757 computer instruction control when operating at T=100 ns.

There are not yet any standardized computational formulas for selecting number of levels, line length, and overmeasure so they are based mainly on the experience of the designers.

In the process of designing the 757 computer, it was stipulated that within one pulse (T=100ns) the number of logic transmission levels permitted would be 17.5, routing length would be 2 m, the delay after loading each gate would be 4 ns, and the delay for each meter of routing would be 6 ns. Thus,

$$\Delta = T - t_{pd} \cdot n - l \cdot t_{dl} = 100 - 4 \times 17.5 - 2 \times 6 = 18 \text{ ns}$$

i.e., Δ takes up 18 percent of the cycle.

There have been various ways of considering whether or not determining number of levels, line length, and overmeasure in this way is a rational exercise. For example, if we compare the overmeasure determined for the 757 computer

with similar class computers from China and abroad (see Table 1), it is clear that the overmeasure of the 757 computer is small, and thus, can the design index determined be implemented in this way?

II. BASIC DEMANDS OF PULSE SYNCHRONOUS SYSTEMS ON D-TYPE TRIGGER STRUCTURE

Information transfer in a synchronous logic circuit composed of D-type triggers can ultimately be simplified to transfer of information between register--combinational logic circuits--register (see Figure 1), i.e., the signal is emitted by the source register, and is relayed to the target register through the combinational circuit.

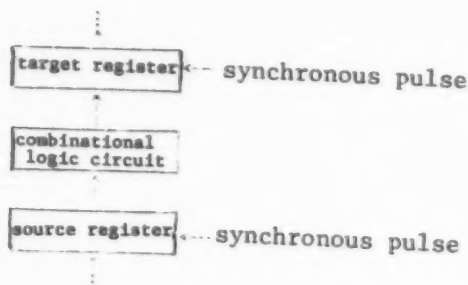


Figure 1

The register is made up of triggers, and for the D-type trigger to operate normally, the fixed intrinsic component properties demand that we do the following:

1. Before the synchronous pulse reaches the action side, the signal to be sent to the trigger should reach the input end. This is what is referred to as the set-up time $t_{\text{set up}}$ (see Figure 2(b)). In the figure a "1" signal must be sent to the trigger thus, before $t_{\text{set up}}$, the signal should be at level "1" (high level in this figure).
2. After the action side of the synchronous pulse, the input signal still must be maintained for a time t_{hold} , otherwise the trigger stage set up may not be correct. This is the hold time. Only after passing the hold time t_{hold} , can the signal "1" in Figure 2 (b) be cancelled and thus after the synchronous pulse action side, the trigger can be held in the "1" state.

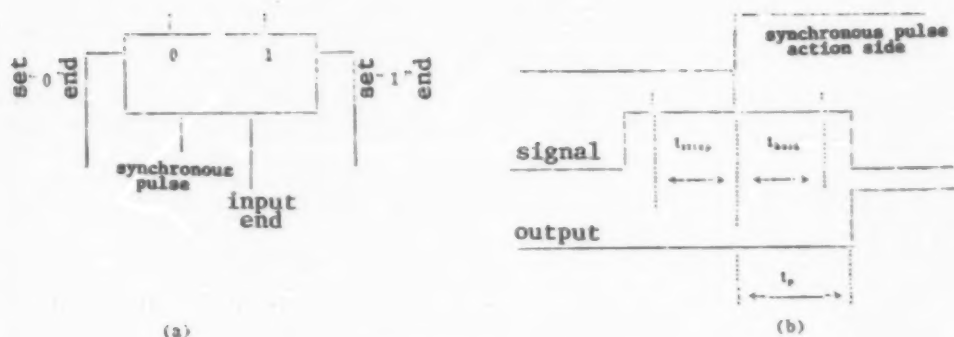


Figure 2

3. While satisfying conditions 1 and 2, after the synchronous pulse action side has, after a certain time t_p , the trigger's output can receive the necessary signal. t_p is the trigger transmission delay time.

Thus, to ensure normal transmission of the signal the following is necessary:

$$T - t_p - t_{pd} \cdot n - l \cdot t_{dl} - \Delta > t_{set\ up} \dots \dots \quad (1)$$

$$t_p + t_{pd} \cdot n + t_{dl} \cdot l > t_{hold} \dots \dots \quad (2)$$

Formula (1) means that after going through trigger delay t_p , gate delay $t_{pd} \cdot n$, routing delay $t_{dl} \cdot l$, and taking into consideration a certain overmeasure Δ , the signal can still reach the trigger input before $t_{set\ up}$, and for this reason the logic series and routing length should be provided and a certain overmeasure should also be provided. If the demands of formula (1) are not satisfied in the design and implementation process, signal relay errors will occur. Formula (2) means that the signal should not be terminated before t_{hold} has ended since $t_p > t_{hold}$ in D-type triggers, thus even when a trigger sends the signal directly to another trigger without going through a logic link, i.e., when $t_{pd} \cdot n + t_{dl} \cdot l \approx 0$, the demands of formula (2) are also satisfied.

However, when the synchronous pulse is not completely registered, such as when there is a backshift in the synchronous pulse of the receiving end, the signal may be terminated before t_{hold} is concluded, destroying the demands of formula (2), creating an information relay error and this is a so-called "catch-up" problem.

III. PROBLEMS ENCOUNTERED IN DESIGN

Instruction control is a constituent part of the 757 vector computer. Instruction control carries out the functions of call instructions, access instructions, analysis and machine-instructions, execution part instructions, entry or exit interrupt, and entry double calculations and monitoring.

Instruction control uses 8628 block modules, 233 block cards, and 8140 circuits.

The entire instruction control is packed on two baseboards 1640 x 524 mm.

In the instruction control design process there were problems concerning the logic chain, primarily two in number: one was the number of logic levels actually useable, and the other was the routing length. These problems will be presented below:

1. Number of logic levels actually useable

(1) Pulse formation and distribution [fentui [0433 2236]]: Implementing the instruction control's beat control operation method demands the formation of control pulses $M_0, M_1, M_2, M_3, M_{j1}, M_{j2}, M, M^*$. The machine's operational state determines which of these pulses is to be issued. The control instruction working pulse serves as the source for these pulses.

These pulses are the synchronous pulses of the trigger components. Since the number of synchronous points is large and there is a limit to the load ability of the pulse distributor (there is one load board for each pulse output line), an entirely synchronous working pulse can be formed only after going through two or even three levels of distribution. Thus, from the instruction control source pulse M_3 to the formation of the synchronous point control pulses takes time for spot use of 4-5 levels.

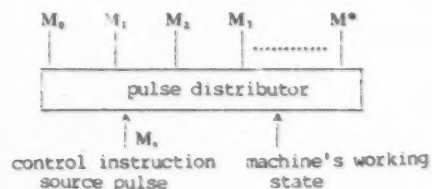


Figure 3

(2) Lockout of pulse: In the instruction control working process, there are two reasons for demanding a stop work pulse.

The reason for first type of lockout pulse is production of a correlation in the operational process of instruction control which requires a lockout pulse to wait until after the correlation has been dissolved before continuing work.

The reason for the second type of lockout pulse is detecting trouble in the operational process of instruction control. At this time, the issuance of the next working pulse should be locked out on the beat in which the trouble occurs so as to retain the current state and roll it in for double calculation or so as to retain the current state for manual or diagnostic program investigation of the error.

Because there are many (86) relational lockout pulse and trouble lockout pulse points and the number of component fan-ins is limited, it also takes 2-3 levels for the bus signal to form the lockout pulse.

From (1) and (2) we can see that in the 757 vector computer the number of logic levels that can actually be used is around 10 (9.5-11.5).

2. Measures adopted in design

The following measures were adopted to design the combinational logic circuits within the range of 10 levels:

(1) Number of compression levels: find the combinational circuit which is long in number of levels and compress it. For example, the circuits which formed the sums of the address adder was reduced from the original 5.5 levels to 5 and parity formation from 11.5 levels to 7.5. Of course doing this increases the volume of equipment correspondingly.

(2) Changing working mode: changing the link and working modes which were insufficiently rational to begin with to reduce the number of levels.

For example, the original design included semiconductor memory which had a read-out register. This required one beat after the read-out semiconductor memory address was given (i.e., the time from when the synchronous pulse A was issued until synchronous pulse B was issued) for the read-out contents to reach J_z .

The original working mode used the concept of magnetic core storage and did not take into consideration the characteristics of semiconductor storage, i.e., that if one wants to give a specific address then one can obtain a stable output, and added an unnecessary register J_{dz} between the J_d and J_z registers.

After improvement, the J_{dz} readout register was eliminated and this both reduced the number of levels and saved on equipment.

(3) Rational determination of check time: The parity check circuit is a combinational circuit. Its output can change at anytime but only during check time does the parity check output have any meaning and thus for some multiple beat working combinational circuits, the last beat of a multiple beat should be checked to avoid incorrect polarity. For example when executing a transfer instruction, the address adder first should form the transfer address, then the discrimination circuit should determine whether or not this address is outside the limits.

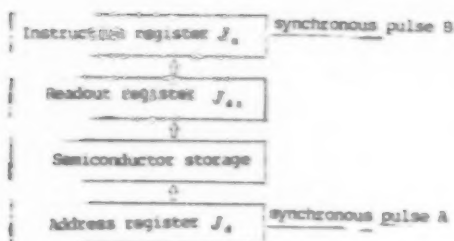


Figure 4

These two operations take two beats of logic. For this reason, check time should be placed at the end of the second beat because this is rational. Otherwise, checking each pulse may cause misrecognition of an operation between two beats and this is irrational.

3. Routing Length

Routing length is directly related to the number of components used, the packing density, and the structure of the base. If few components are used, packing is dense, and baseboard structure is tight, then routing length will be short, otherwise it will be longer.

Instruction control uses 8628 components (not including spares) and 233 cards. Even when the baseboard configuration is dense (4724 circuits/m²) it is very difficult for each component link to be less than 2 m. The following measures have been adopted to resolve this problem:

(1) Compact assembly has been adopted so as not to increase the number of baseboards: In the late stages of design, when completing the instruction control definition of functions, we did our utmost to control and reduce the number of components and cards used, with the aim of compressing the entire instruction control into two boards to reduce routing length.

The result of compaction was that the two boards had a total of 240 card positions of which 233 were used, including one pulse source card which had to occupy four card positions because of manual adjustment frequency. Thus, there were two empty card positions on each baseboard.

(2) Division of subcomponents: Depending on function, instruction control was divided into eight subcomponents: call instruction, fetch instruction and analysis instruction, address operation, change address and change buffer control, interrupt and uniform numbering register, recovery and monitoring, pulse allocation and pulse lockout, and control and display. These subcomponents all have a certain degree of independence, there are many links between them, few links outside them, and when installed on the baseboard, these subcomponents occupy an independent continuous area to reduce the routing length between subcomponents.

(3) Determining the priority arrangement sequence of the baseboard: When dividing up the baseboard, a plan is adopted based on the relations between subcomponents and the link relations of instruction control and other control components. This plan makes access instructions, analysis instructions and pulse distributions to be the core; call instructions, address operations, change address and buffer control to be the middle; and interrupt and uniform numbering registers, recovery and monitoring to be the outer distribution scheme. Thus, the layout takes into consideration the number of natural links between subcomponents, reduces the routing length of the core and the middle sections, and also uses the characteristics of short logic levels of peripheral subcomponents which can relax routing demands.

(4) Compressing the number of levels in instruction control interface leads: The short-time problem introduced by shortening the length of leads between the instruction control and other control components demanded that at the time of design the instruction control output signal be generally permitted to pass the distribution gate only after entering the trigger, immediate output is not permitted to pass through the combinational logic circuit and then be output. Individual output signals which had to pass through logic combination and which were also long in number of levels should use trigger separation. As concerns signals input to instruction control, they generally did not go through logic combination after reaching instruction control and were only permitted to be immediately used or entered into the trigger after going through distribution to be saved.

The number of logic levels and the routing lengths of some typical instruction control logic links after adopting the above measures are given in Table 2:

Table 2

Selected logic chain number	1	2	3	4	5
Original number of logic levels	16	16	14.25	18	17
Original number of cards	7	6	5	6	8
Length of link between cards (m)	2.27	3.78	3.49	2	2.9
Length of link within cards (m)	1.44	1.95	2.00	2.28	2.17
Total length of original circuits (m)	3.71	5.73	5.49	4.28	5.07
Time of original logic chains	45.1ns	111.2ns	106.6ns	109.4ns	111 ns
Number of logic chain levels	15	15	13.25	17	16
Number of cards	6	5	4	5	7
Length of links between cards (m)	1.79	3.12	3.69	1.49	2.15
Length of links within cards (m)	1.3	1.78	1.82	2.1	1.95
Total circuit length	3.09	4.9	5.51	3.59	4.10
Logic chain time	46ns	100.7ns*	93.2ns	99.9ns	99.27ns
Measured logic chain time	47ns	73ns	83ns	92ns	92ns

* Number is an estimated value. There is a statistical error creating a large discrepancy with the test value.

IV. PROBLEMS ENCOUNTERED IN DEBUGGING

The methods and measures we adopted in the stage of debugging the frequency range were:

1. Test procedure

To inspect the frequency range strictly we wrote a 36 segment control instruction inspection program. Each segment had 64 statements and each segment program operational cycle was 150-600 pulses so that the oscilloscope viewed the wave form detail of each beat.

2. Frequency range standards

Debugging the correctness of instruction control logic links is done at low frequencies (under 1 MHz). In this way, trouble caused by electronic technology and components with poor characteristics can be avoided so that the debugging is limited to the range of correct logic. Also, the goal of frequency debugging is, on the one hand, to eliminate operational errors caused by technology and components with poor characteristics, and, on the other hand, to measure the highest operational frequencies. In a large-scale pulse system, because of the extraordinary complexity of the signal relay paths and combinational situation, the correctness of operation cannot pass as standard at a set frequency by several segments of inspection program. For example, when the logic chain through which a group of signals is going exceeds the clock cycle, it is possible that trouble with this group of signals cannot be discovered at the check points. When the frequency is low it is possible to discover the trouble with this group of signals at the check point. This is commonly referred to as the phenomenon of "able to work at normal frequencies but not able to work at variable frequencies."

For this reason, determination at the time of frequency range debugging, requires a comprehensive 36 segment inspection program under continuously changing conditions from low frequencies (single pulse) to high frequencies for normal operation. The working range determined in this fashion is called the working frequency range. Practice proves that after debugging such a range and putting it into operation there are no reoccurrences of hidden frequency problems.

3. Trouble shield and trouble shooting

There are two ways of determining whether or not a test program is operating normally when the frequency is changing. One is to set a program comparison point (a soft check point) in the inspection program. For example, if the results of the comparison point and the anticipated results are not the same, then the machine turns to generalized shut-down state showing that the signal relay path at this frequency is not clear or there is some parity check error in the relay process. The other one is to use the parity check point built into the computer. If a parity error occurs in the debugging process of working frequency range, then the lockout pulse holds the current state. This means that the logic chain is too long for this frequency and it can no longer guarantee normal relay of the signal between registers.

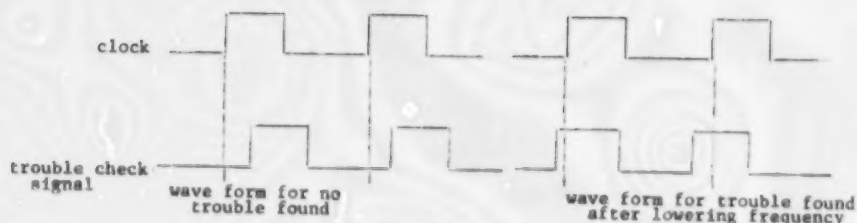


Figure 5

In the process of actual frequency debugging, when the frequency is made higher if a parity error lockout pulse occurs, this also means that the parity check point set-up has basically overlaid the instruction control.

Under such conditions it is possible to pursue the source using the signal of the trouble lockout pulse. When the frequency is steadily changed from low to high we look for a lockout pulse signal to appear. If a lockout pulse signal appears, then it can be pursued level by level until the source of the trouble is found, that is until the long logic chain is found at the given frequency. This is the troubleshooting method. This method goes step by step using an oscilloscope and is rather troublesome.

The trouble shield is a less troublesome method. The basis of this method is that each problem can be shielded. If a problem appears at high frequency and the computer is stopped, it requires only the use of a single probe to test the shield point by point and after the shield points have been selectively paired, the computer is restarted and the inspection program can again operate normally. Thus the shield points facilitate our finding the source of the trouble.

Troubleshooting and shielding can be used in combination. In this way the random nature of troubleshooting on a large-scale pulse system can be reduced.

Results of Debugging

After eliminating frequency trouble created by trouble in the primary components, the maximum operating frequency of the inspection program is 8.2 MHz (cycle is 122 ns), and this is the overall result of logic design, engineering design, and structure design.

So that it can operate at working frequencies below 10 MHz, in addition to the above measures, we also used the concept of pulse system quasi-registration as a supplementary measure.

In the second section of this article we have already assumed that the time at which synchronous pulses get to the register is equal, that is, they are aligned, thus, for signals transmitted between any two groups of registers, the

cycle time is an equal value T , but the number of combinational logic circuit levels between any two groups of registers is not necessarily equal, thus when raising the working frequency, for certain signals, the number of logic levels is clearly tight and can even cause trouble. For some other signals, although the frequency is raised, the number of logic levels still has an overmeasure and it is just because of this difference that we can hold back the synchronous pulse of a long chain's target register (if the next level's logic chain is not tight) and lengthen the cycle of a long logic chain, at the same time reducing the cycle of a short logic chain so that trouble is eliminated and the overall working frequency is increased, as illustrated in Figure 6.

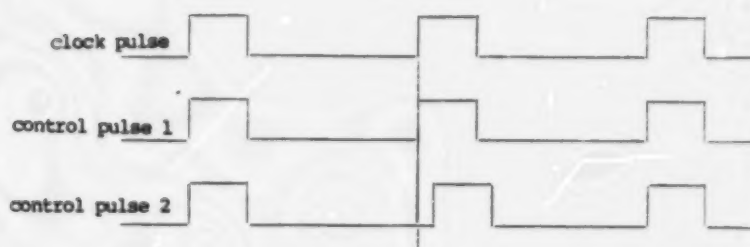


Figure 6

After the quasi-registration measures were adopted, a total of 13 logic chains (7 pulses + 5 potentials) were adjusted so that the instruction control working frequency reached 11.2 MHz ($T=89\text{ns}$).

It should be noted that this quasi-registration method can only serve as a supplementary method and can only be used in the debugging process of similar computers.

Using the above methods was only to satisfy the frequency norms and demonstrating the tightness of the logic chains in the original design.

V. CONCLUSION

The number of logic levels actually used is related to the complexity of the synchronous pulse system, the pulse distribution mode and the lockout mode. When the registers are limited to a single level structure the number of logic levels actually useable determines the quantity of components. Reducing the number of useable levels increases the components used. Thus when determining the number of logic levels it is necessary to balance several factors otherwise contradictions will appear and lead to a lowering of the working frequency.

2. Routing length is related to packing density and the number of components used. In a large scale computer with the packing configuration and density similar to that of the 757 vector computer, it is very difficult to keep the routing length within 2 meters. It is even hard to realize in the interface part of the control component. For this reason, when determining routing length the interface routing should be clearly defined and if routing is greater than a certain length or greater than the routing of a certain number of logic levels, then it is necessary to adopt isolation measures. And after isolation, redesign the logic relations of the interface.

3. Redetermining the number of logic levels and the routing length when the above two questions have been thoroughly considered is also difficult, thus when designing a certain degree of overmeasure should be provided. On the basis of the situation involving the several computers in Table 1, it is best if the overmeasure is above 20 percent.

In summary, pulse system and logic chain length is a system index for designing a computer and detailed and comprehensive proofs should be carried out in the design stage with regard to the number of components, packing density and logic divisions and a certain overmeasure be reserved.

This article was written under the guidance of Comrade Li Shuyi [2621 2885 6318] to whom we express our heartfelt thanks.

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FAULT DIAGNOSTIC PROGRAMMING FOR ALU IN THE 757 VECTOR COMPUTER

Beijing JISUAN YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese
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[Text] I. Introduction

Fault diagnostics for the arithmetic logic unit (ALU) of the 757 computer is realized by software that requires certain hardware support, peripheral diagnostic devices, and methods for detecting and isolating malfunctions in extremely small regions. A fault-location program is used to search a fault dictionary for malfunctions in order to locate and report the source of the trouble down to the primary circuit board level. The development of data structures and fault dictionaries and methods for automatic retrieval have been investigated in actual computer installations and useful results have been obtained. No human intervention is required anywhere in the diagnostic process, and the implementation of automatic diagnostic methods greatly enhances the usefulness of computing machinery and facilitates maintenance.

The following three areas are of primary importance in the software implementation of fault diagnostics for ALU's: 1) selecting the test code; 2) writing the fault diagnostics program; 3) compiling a fault dictionary.

Many other tasks are also involved in developing a fault diagnostic program. The most important of these is to organize the structure of the test data and write software to control the test process, handle the fanning in and out of messages, and automatically search through the fault dictionary and report the diagnostic results while the automatic tests are in progress. The layout and structure of the fault dictionary should facilitate adding to the dictionary and retrieving information from it in accordance with the instructions in the diagnostic program.

Although much work has been published in China and abroad on test code generation for fault diagnostics, few results have been reported regarding the diagnostic programming or fault dictionaries, both of which are indispensable parts of the diagnostic system. This paper is concerned with introducing the operating principles involved in the fault diagnostic program (FDPM) and

fault-dictionary (FDIC) of the arithmetic logic unit. Implementation techniques and various data structures are discussed.

II. ALU Fault Diagnostic Program

The FDPM program is loaded into the system when a hardware failure occurs in the ALU, as evidenced by a repeated failure in performing an operation. In order to simplify the diagnostic procedure, the ALU is divided into certain logic blocks according to structure and the test is carried out block by block. The test codes are fanned into each logic block by calling in the test routine resident in the FDPM that load peripheral devices through an interface. The test program also records the response of the logic block to the test code (the contents of this response are called the received value) and stores it in the diagnostic peripheral device in a Test Results file. After the entire logic block has been completely tested, the test program collates the received responses. If an error is found (the response differs from the expected value) an ALU malfunction is indicated. At this point, the fault dictionary is automatically accessed and the fault locating routine contained in the FDPM examines each entry in the fault dictionary and the corresponding diagnostic message. When the correct entry has been found, the cause of the malfunction and the faulty circuit board are displayed on a terminal or printed out for servicing by technical personnel. Figure 1 shows a block diagram of the FDPM diagnostic procedure.

[Figure 1 on following page]

k	Name of Current Logic Block Being Tested	Fan-In Data of Logicblock
k + 1	Fan-In Subprogram Number	
k + 2	Fan-In Code (Low 64 Bits)	
k + 3	Fan-In Code (High 64 Bits)	
k + 4	Resetting Commands and Stepping Commands	Control Fan-In Commands If Fewer Than 6, Fill Spaces With 0
k + 9		
k + 10	Fan-In Reclaim Instructions	Data Related to Reclaim Logic-block
k + 11	Masking Value	
k + 12	Expected Value	

Figure 2 Test Scheme

III. Fanning-In the Test Data and Collating the Responses

1. Test patterns: In addition to the actual test codes, additional data bits must be used to accommodate the input terminal (or register) which sends the

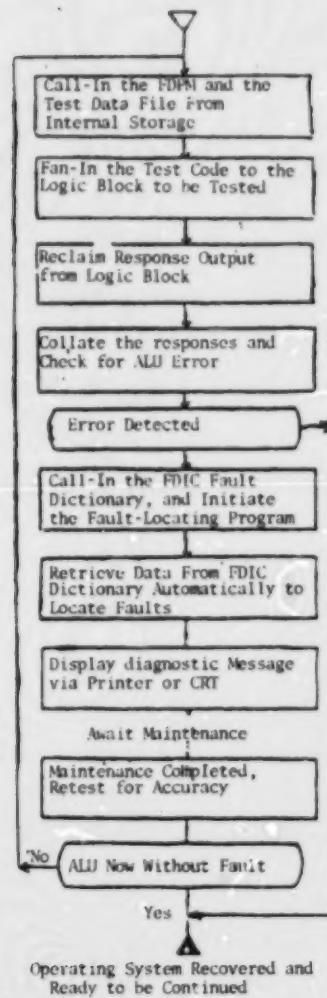


Figure 1 Flowchart for the ALU Fault Diagnostic Procedure

test codes to the logic block; reset instructions and instructions for stepping through the code are also necessary. In order to include these data and instructions in a single test pattern, one must also incorporate the retrieval instructions and the correct responses (expected values) for logic blocks which are not malfunctioning. Figure 2 shows the corresponding fixed data structures for the interrelated test and retrieval data in the test pattern.

This data format facilitates the grouping of related test information together and is a convenient method for organizing large amounts of test data. It also avoids omissions and syntax errors and facilitates programmed examination of the data.

A single text pattern corresponds to carrying out a single test measurement on the ALU. Many measurements and several test patterns are needed to troubleshoot a single logic block, since each block contains from three or four to several dozen devices requiring different test patterns. The internally resident test patterns are handled continuously in the order in which they are called up. When the diagnostic program is started, each test pattern is entered into a directory which is headed by a single 64-bit word with the format shown in Figure 3. The highest 18 bits give the address of the header; this information is used for partial testing during debugging operations or when the computer is off-line.

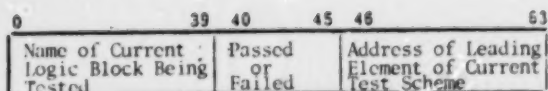


Figure 3 Testing the Directory Character Format

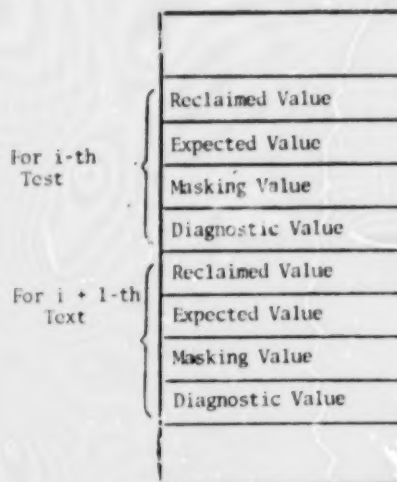


Figure 4 Test Results by Regional Structures

2. Collating the test results: In order to facilitate examination during the subsequent troubleshooting, the FDPDM program also arranges related test data in the same order in which the test measurements are carried out. After each test the results are stored in the four information words shown in Figure 4 (reclaimed value, expected value, masking value, and diagnostic value). The

expected and the masking values are initially contained in corresponding test patterns. The masking value is to point out all relevant word places in the current tests (the place corresponds to 1 in the effective word place); the diagnostic value is formed as follows, i.e., diagnostic value = (reclaimed value $\oplus$ expected value) $\wedge$ masking value. All places of the diagnostic value are called diagnostic places. Fault in ALU exists if the diagnostic value does not equal to 0. A 1 bit in the diagnostic result denotes a discrepancy in the corresponding bit for the reclaimed and expected values and indicates an error at this bit position.

The testing and reclaiming operations are performed on whole words; as a result, the test efficiency is improved because the ALU can handle multi-word bits concurrently during the test procedure.

3. Detecting the presence of a fault: Two methods can be used to decide whether or not an ALU malfunction has occurred--one can attempt to reach a decision after each test measurement has been completed on every logic block, or, one can wait until all the tests on the logic block have been performed and reach a decision on a block-by-block basis. If the first method is used, it is not necessary to continue testing the remaining components in the logic block once a fault has been located; this procedure is thus quicker, but the controlling software is more complicated. If the second method is employed, roughly the same amount of testing time will be required regardless of when the fault is detected; however, the software implementation is simpler. The FDPM program employs the second method, which may be described in more detail as follows.

After all the tests have been completed for a given logic block, the test result memory locations are accessed sequentially to analyze the diagnostic words. If all the bits in a diagnostic word are equal to zero, the program writes all zeros into the directory indicating whether it was pass or failure in the entry corresponding to the current test. These bits indicate the test has been passed. If not all of the locations in the diagnostic value are not equal to zero, the program sets bits all 1's, indicating an ALU failure. In this case the diagnostic program branches to a subroutine which consults the fault dictionary--the fault location program accesses and retrieves data from the fault dictionary--until the problem is identified.

IV. The Fault Dictionary

1. Generating the fault dictionary: As an illustration, consider the logic block on circuit board A101, whose circuit is shown in Figure 5. The signals along the gate K and the code input lines b_1 , b_2 , b_3 all originate from different circuit boards, and the code output lines c_1 , c_2 , c_3 also go to different boards. Table 1 illustrates the complete fault-testing and locating procedure for detecting a single malfunction in this logic block (we assume that b_1 - b_3 , i.e., their signal levels are either both 0's or both 1's).

Table 1 Complete Procedure for Fault Testing and Locating for the Logic Block in Fig. 5

(1)	(2)	(3)	Detectable Fault					
			k			b		
			sa 0	sa 1	sa 0	sa 1	sa 0	sa 1
1	1	1	1		1		1	
2	1	0				1		1
3	0	1		1				1

(1) Test Number; (2) Value from Input Terminal;
(3) Accurate Output Value

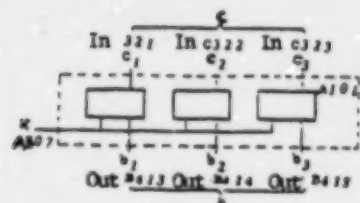


Figure 5 An Illustration of the Logic Block Circuit

Table 2 Fault Dictionary for Testing the Logic Block in Fig. 5

Entry	Source of Fault		Test # Succeeded	Test # Failed	Possible Faulty Circuit Boards
	Logical Name	sa0/sa1			
1	k, b, c	sa 0		1	A 101, A 507, C 321, C 322, C 323, B 413, B 414, B 415
2	c	sa 1		2, 3	A 101, C 321, C 322, C 323
3	k	sa 1	2	3	A 101, A 507
4	b	sa 1	3	2	A 101, C 413, B 414, B 415

Table 2 shows that several different error sources c, k, and b generate the same signal sa0, i.e., their test responses are identical. In this case, all of the boards from or to which b_1 - b_3 , c_1 - c_3 and k receive or send signals must be suspected if a fault is detected. If there are many bits (lines) involving different circuit boards, the list of circuit boards may be quite long.

Examining Figure 5 reveals that a gate failure will generally result in multiple bit errors; on the other hand, if one of the code bits is wrong, only one bit in the output will generally be in error. This difference is helpful in distinguishing and more precisely identifying these two kinds of faults from their different characteristic bit patterns. Of course, in order to do this one must increase the number of entries in the dictionary. Table 3 shows how the fault dictionary in Table 2 can be enlarged to analyze the incorrect bit patterns.

After the test program has detected a fault, the malfunctioning logic block has been identified, and the results are available for all of the failed tests, the next step is to consult the fault dictionary to identify the failed circuit board.

2. Structure of the FDIC fault dictionary: We see from the above discussion that the fault dictionary basically describes the relationships between a faulty circuit board and the responses of a malfunctioning component in the corresponding logic block to the set of diagnostic tests. In general, the overall response of a malfunctioning component to the battery of tests can be characterized in terms of which tests were passed and which were failed.

Each logic block corresponds to a section (directory) in the dictionary which has the same name as the corresponding logic block and contains several entries, each consisting of a number of items. During automatic data retrieval from the dictionary, each item in each entry must be represented symbolically in conformance with certain structural requirements in order to facilitate programmed retrieval. The fault dictionary is usually quite a large file which is stored in an external memory device during the testing stage and loaded into core only when it must be accessed for retrieval.

Table 3 Expanded Fault Dictionary for Detailed Error Analysis of the Tested Board in Fig. 5

Entry #	Source of Fault			Number of Test Passed	Number of Test Failed	Position of Diagnostic Value = 1	Possible Faulty Circuit Board
	logical name	sa0/sa1	group/bit error				
1	k	sa 0	group		1	1,2,3	A 101, A 507
2	k, b	sa 0	bit		1	1	A 101, B 413
						2	A 101, B 414
						3	A 101, B 415
3	c	sa 0	bit		1	1	A 101, C 321
						2	A 101, C 322
						3	A 101, C 323
4	k	sa 1	group	2	3	1,2,3	A 101, A 507
5	k	sa 1	bit	2	3	1 or 2 or 3	A 101,
6	c	sa 1	bit		2,3	1	A 101, C 321
						2	A 101, C 322
						3	A 101, C 323
7	b	sa 1	bit	3	2	1	A 101, B 413
						2	A 101, B 414
						3	A 101, B 415

Table 4 Representations and Names of all the Terms in the FDIC Fault Dictionary

Item #	Item Name	Representation	
		Prefix Symbol	Rest of Entry Following the Prefix
1	dictionary section names and entry numbers	F	<section name><entry number>
2	fault source	↑ ↑	<logical name> <sa 0/sa 1> <bit/group>
3	failure condition in current logic block	C [1]	<condition number>
4	test to be passed	Y [2]	<test number>, <test number>, ..., <test number>
5	test to be failed	N	<test number>, <test number>, ..., <test number>
6	test for locating fault	T	<test number>
7	register for holding responses	R	<register name>
8	bit error	E [3]	(0)/(1)
9	diagnostic bit	:	
10	faulty circuit board	:	<board number> <board number> ... <board number>

[1] The second symbol ↑ is a terminator;

[2] Some faults may be indicated using Y, N terms or just an N term alone; in this case the C or the C, Y terms may be omitted;

[3] This term is omitted for multiple bit errors in which some of the wrong bits are 1's and some are 0's.

Various prefixes and tags are added to the entry items in the FDIC fault dictionary in order to assist the automatic retrieval process. Table 4 lists the names and representations of each of ten items, the maximum number that any entry can contain. An entry can be formed by stringing names together in accordance with the syntax in Table 4. For example,

FYWWC 1↑K←0 SA 0 SGL↑C(37)N(115, 210)T(115)R(E)E(1)
P 0/P 60(4):B 114, P 1/P 61(4):B 124, P 2/P 63(4):C 103, P 3/P 64(4):C 108.

Since all the items in the FDIC are represented using ASCII coded characters, the entire FDIC fault dictionary is an ASCII file.

3. Representation of the diagnostic bits: The ALU has a 64-bit word length and the digital code is carried by lines which originate and terminate in numerous circuit boards; when analyzing wrong bits, one therefore attempts to localize the source of the trouble and pinpoint the failure more precisely by minimizing the number of boards that must be investigated. It is therefore not enough for the fault source items in the FDIC to merely list the logical name of the malfunctioning component and the nature of the failure--a quick method is also required for exhibiting the relationships between the partial bits in the diagnostic word and the circuit board which is malfunctioning.

The FDIC uses the following types of diagnostic expressions.

1) P-expressions: In this case one wants to check if a certain diagnostic bit is equal to 1. This diagnostic bit is distinguished by the prefix symbol P. The two types of relations, "and" and "or," between the diagnostic bits may be described as follows:

① The "or" relation is denoted by an expression of the form $Pi_1, Pi_2, \dots, Pi_n$ and is satisfied if and only if at least one of the bits $i_1, i_2, \dots, i_n$ is equal to 1.

② The "and" relation is denoted by $Pi_1Pi_2\dots Pi_n$. This relation is satisfied if and only if each of the bits $i_1, i_2, \dots, i_n$ is equal to 1.

③ The syntax for the "or" relation can be simplified to $Pi/Pj(k)$, where k is the step length. This relation is satisfied if and only if at least one of the bits $i, i+k, i+2k, \dots, j$ is equal to 1.

④ The "and" relation can also be expressed in the simple form $Pi-j(k)$, which is satisfied if and only if all of the bits $i, i+k, i+2k, \dots, j$ are equal to 1.

Expressions of the form ① and ③, ② and ④ can be combined; e.g., $P8/P15, P22, P24$, and $P3-7, P11$, respectively.

⑤ There is also an "and or" relation which has the form $\langle \text{and relation} \rangle / \langle \text{and relation} \rangle / \dots \langle \text{and relation} \rangle$. The separating slashes "/" indicate that the

various "and" expressions are to be "or"-ed. That is, the entire relation is satisfied if and only if one of the "and" relations in the chain holds.

2) Q-relations: These are used to test if a specific diagnostic bit is equal to zero; these bits are denoted by the prefix Q. The form of the Q-expressions is completely analogous to the form of the P-expressions, from which they can be obtained simply by replacing P by Q. For example, $Q_1Q_2...Q_n$ holds if and only if all of the diagnostic bits $i_1, i_2, ..., i_n$ are equal to zero.

3) @-relations: These are formed by adding the symbol @ in front of a P-relation; e.g., @P1P3 or @P0/P63(4).

The meaning of an @-expression is similar to that of the corresponding P-expression, except that in order for an @-expression to be satisfied it is not enough that the corresponding P-expression hold (i.e., that the relevant diagnostic bits be equal to 1)--in addition, all of the other diagnostic bits not specified in the relation must be equal to zero.

The items specifying the diagnostic bits are paired with the items which characterize the faulty circuit board in each entry in the FDIC fault dictionary. The pairing can be iterated and the elements in a pair are separated by a comma ","; the last pair in the sequence is followed by a semicolon ";" which serves as a terminator.

V. Retrieval From the Fault Dictionary and Location of the Malfunction

Figure 6 illustrates the retrieval and location procedure.

1. Make a subdirectory: A subdirectory heading is provided for each section of the dictionary file using the format shown in Figure 7.

2. Search for failed tests: The fields indicating whether a test was passed or failed are scanned within a directory. The scanning process terminates when a field with all 1's is encountered, and the name (NAME) of the failed logic block for this test is read from the directory.

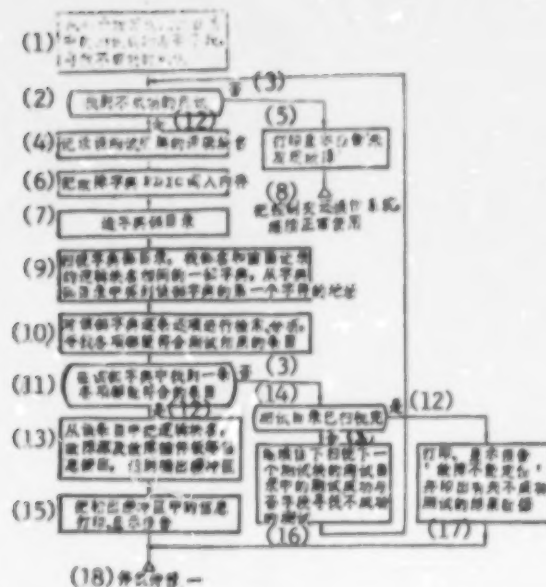


Figure 6. Block Diagram Illustrating Retrieval From Fault Dictionary and Dictionary Locations

Key:

1. Scan all the test passed/test failed fields in the directory and look for failed tests
2. Failure found
3. No
4. Record name of logic block which failed test
5. Display message "no error found"
6. Call in the FDIC fault dictionary
7. Create a dictionary directory
8. Return control to the operating system and continue normal operation
9. Search the dictionary directories for the section whose name and prefix symbol match with the logic block name, and retrieve the address of the first symbol from that directory
10. Search through the entries and items of this directory to see if any correspond to the test results
11. Was a match found?
12. Yes
13. Extract the name of the logic block, source of malfunction, faulty board, and other information from the matching entry and send it to an output buffer
14. Search of test directory complete?
15. Display information in output buffer on terminal screen and print it out
16. Continue searching through the test failed/test passed fields for the next logic block in the test directory and look for failed tests
17. Print out and display message "Unable to locate failure" and print out the relevant data for the tests that were failed
18. Stop the computer for repairs

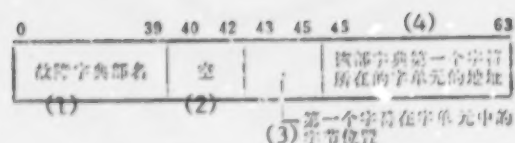


Figure 7. Directory Character Format in the Fault Dictionary

Key:

1. Section heading
2. Unused
3. The byte position for the first character in the word cell
4. Address for the word cell containing the first character for the current dictionary section

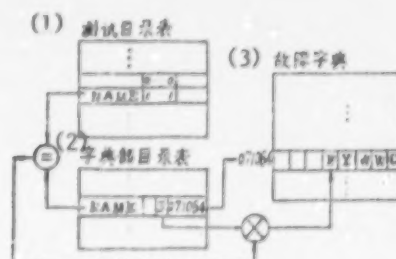


Figure 8. Procedure for Searching for the Location of the Leading Characters in the Fault Dictionary

Key:

1. Table of test directory
2. Table of dictionary section directory
3. Fault dictionary

3. Find the dictionary section to be examined: Each logic block corresponds to a section of the dictionary with the same name. In order to speed up the dictionary search, the fault dictionary is called in only when tests have been failed, and only the section with the same name as the failed logic block is searched. The schematic in Figure 8 shows how the leading character in the section heading is located.

4. Examine the dictionary and locate the fault: All the entries in the relevant section of the fault dictionary are examined by inspecting each item for a match with the test results. If a matching entry is found, the dictionary search terminates successfully and the malfunction has been located; the source of the trouble and the faulty board can then be reported using information in the matching entry. Figure 9 illustrates how the dictionary is examined.

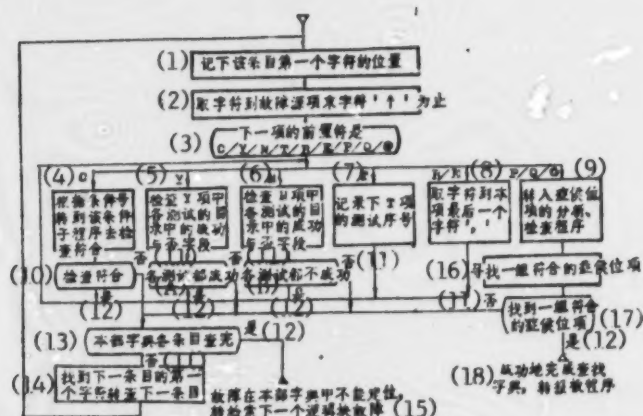


Figure 9. Flow Chart Illustrating the Use of the FDIC Dictionary

Key:

1. Record location of first character of current item
2. Read characters in the fault source item until the terminator ↑ is reached
3. Prefix of next item is ...
4. Use the condition number to execute the corresponding subroutine and look for a match
5. Examine all the test passed/test failed fields in the Y item
6. Examine all the test passed/test failed fields in the N item
7. Record the test numbers in the T item
8. Read all characters in the current term up to the last symbol "↑"
9. Execute program for examining and analyzing the diagnostic bits
10. Examine characters
11. No
 - A) All tests passed?
 - B) All tests failed?
12. Yes
13. All items in current dictionary section examined?
14. Find first character in next entry and continue examining
15. Unable to identify fault within current dictionary section; search to see if the next logic block is at fault
16. Search for a group of corresponding diagnostic bits
17. Corresponding diagnostic bits found?
18. Dictionary search successful, execute program to report the faulty board

Service technicians must examine the fault source, the E, and the R terms in each item contained in the dictionary entry during the repair stage; the C, Y, and N items and the diagnostic bits must be checked one-by-one to see if they correspond; the test numbers contained in the T item are used when the diagnostic bits are examined. If examination of any of the C, Y, and N terms reveals a mismatch, the entire entry fails to match the test results and the

next entry is consulted. If these three items all match, the groups of diagnostic bits in the diagnostic item are inspected; if one of these groups matches the test result, the entire entry matches and the fault has been successfully located. The number of the faulty board is present in the "faulty board" item which is paired to the groups of matching diagnostic bits. This process is illustrated by Figure 10.

It should be noted that the sequence of diagnostic bits in the diagnostic word is determined by the masking word (ie., by the mask bits which are equal to 1). For example:

masking value: 00001111110...011111
 diagnostic value: 10000010000...000000
 diagnostic bit positions: 012345 678910

Thus, only bit 2 in the diagnostic field is equal to 1.

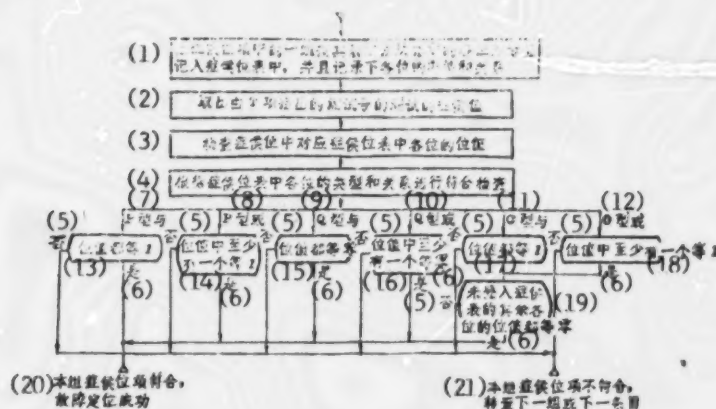


Figure 10. Flow Chart for Examining Correspondences in the Diagnostic Bit Field

Key:

1. The diagnostic field contains a group of bits which is specified by the diagnostic expression (cf. Sec. 4, part 3). Record these bits in the diagnostic bit table, together with the type of each bit and the relation containing them.
2. Get the diagnostic fields for the tests listed in the T item.
3. Check the bit positions of the bits in the diagnostic field which match the ones in the diagnostic bit table.
4. Check to see that the type and relation for each of these bits matches the corresponding data in the diagnostic bit table
5. No
6. Yes

[Key continued on following page]

[Key for Figure 10 continued)

7. "and" P-type
 8. "or" P-type
 9. "and" Q-type
 10. "or" Q-type
 11. "and" @-type
 12. "or" @-type
 13. All bits 1
 14. At least one bit is 1
 15. All bits 0
 16. At least one of the bits is 0
 17. All bits 1
 18. At least one bit is 1
 19. All of the remaining bits (not entered in the diagnostic table) are equal to 0
 20. This group of diagnostic bits matches, fault has been located
 21. This group of diagnostic bits does not match; check next group of bits or next entry
5. Error reporting: When a matching group of diagnostic bits has been found, the information from the corresponding Faulty Board item (i.e., name of the logic block) is read and output to a printer or terminal, where it is analyzed by repair technicians. If necessary, the technicians can also instruct the computer to print out the data on the failed tests. In those instances when a fault has not been located, this information may be helpful for human analysis of the cause.

VI. Repairing the System

After the technicians have repaired the malfunction, the system can be retested. If no failures occur during continuous operation, control is transferred to the operating system and normal operation resumes (it is not necessary to perform a cold restart).

VII. Conclusions

The features of the fault diagnostic program and fault dictionary developed for the ALU of the 757 computer may be summarized as follows.

a) A field (pattern format is used to represent the test data and other information; b) data retrieval from the dictionary and fault location are programmed, and the entire fault diagnostic process is highly automated; c) programmed retrieval is facilitated by using distinctive prefixes in all of the items in the fault dictionary; d) the diagnostic efficiency is increased because full data words are examined concurrently; furthermore, measures are taken to limit the range of possible fault locations during the stage when the wrong bits are analyzed; e) the facilities available for checking syntax and reporting errors can handle large amounts of data.

Because the system is new, the FDIC fault dictionary still has a few shortcomings, of which the most serious are:

1) Although the accuracy in locating fault by analyzing wrong bits is increased, this is at the cost of considerably increasing the number of entries in the fault dictionary. If a more concise method could be found for expressing the relevant information, fewer entries would be needed and the size of the dictionary could be reduced. 2) The diagnostic syntax was developed by a process of ad hoc additions made at various times; as a result, it is not always as simple and clear as it should be.

We have tested the FDP fault diagnostic program for some time and it has performed as expected. Approximately 10 seconds is required to output the diagnostic report after a failure has been detected, regardless of whether the trouble can be quickly repaired or not.

Xu Jun [1776 3182], Sheng Chuanying [4141 0278 5391], Zhang Hua [7022 5478], Zheng Shuhua [6774 3219 5478], and several other people participated in the writing of this article.

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MAGIC ORDER MERGE-SORT ALGORITHM

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[Article by Zheng Zhijie [6774 2535 2212], Institute of Computing Technology,
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[Text] Abstract. A magic order merge-sort algorithm is introduced. This algorithm has a simple regulated control form, an overall characteristics of harmonious symmetry, and has higher application values.

The derivation of an algorithm is given from a biquadratic linked merge algorithm: the magic merge-sort algorithm. Since the distance between comparands in each pass of the execution of this algorithm form an array whose elements are such that, according to the Oriental mathematical tradition, they form an unusual set with combinatorial meaning, called the magic numbers. The author borrows this term to call it "the ought to algorithm," to emphasize the important effect of describing the relationship between the distance value and place value within the algorithm. It should be pointed out that this is not a new algorithm, and that its external form is the same as Batchers' odd-even sort algorithm given in reference [1]. However, this is independently derived by the author from another viewpoint. The algorithm utilizes the control form of the distance value and numerical place value to fundamentally change the view on the algorithmic function, thereby overcoming the deficiency of large operational values of the algorithm in reference [1].

I. The Principle of the Algorithm

The basis of a merge-sort algorithm is merging. The sorting is formed by repeated mergings. Figures 1 and 2, respectively, give a scheme and an example of a merging and sorting problem, and they are given to show the algorithmic process. One needs to carry on a mixed preprocessing while merging two ordered arrays, but this process is not required in sorting.

Paper received 12 May 1982.

In the following descriptive algorithm, I is the serial number

$$I = \sum_{j=0}^{n-1} I(j) \cdot 2^j, \quad 0 \leq I < N, \quad n = \lceil \log N \rceil, \quad I(j) \in \{0, 1\}.$$

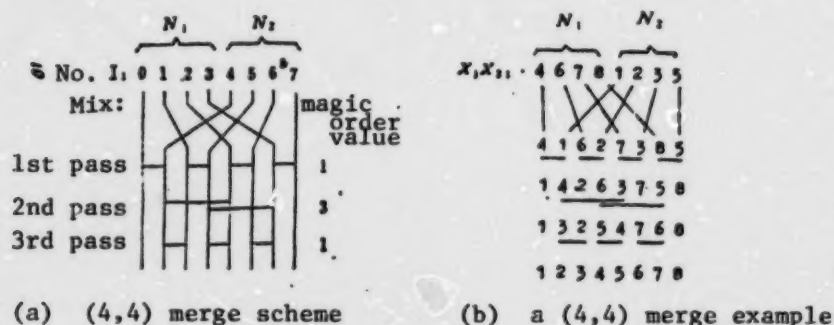


Figure 1 (4,4) merge

In (b) $x_1[0:3] = (4, 6, 7, 8)$, $x_2[0:3] = (1, 2, 3, 5)$

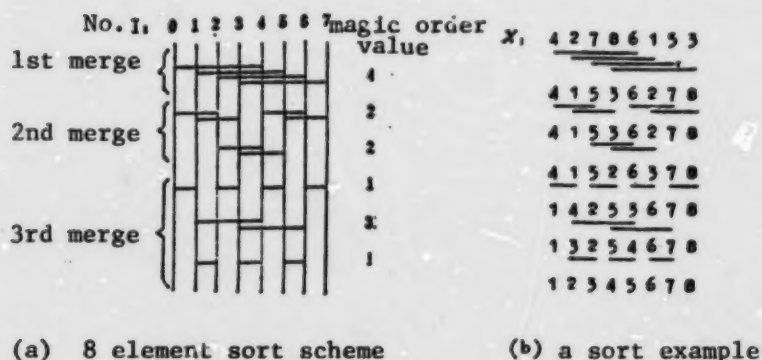


Figure 2 Magic order merge sort, $N=8$

In (b) $x = x[0:7] = (4, 2, 7, 8, 6, 1, 5, 3)$

Method: Magic order merge sort algorithm

Input : $X[0:N-1]$;

Output: $Y[0:N-1]$, X 's one replacement

$Y[i] \leq Y[i+1], 0 \leq i \leq N-2$;

Process: Run magic merge-sort procedure $MOS[N]$. The algorithm is formed by two nested loops. The inner loop executes the completion of merge in each pass and the outer loop ascertains the processing of each merge. The elements to be compared (comparands) are selected in concert with the merge number, pass number, and array serial number, while exiting the outer loop the array elements are arranged in sequence by their magnitudes.

Compare/exchange procedure: $CI[I, J, B, H]$

```

procedure  $CI[I, J, B, H]$ 
do
  if  $I[J] = B$  then do
    if  $X[I] > X[I + H]$  then do
       $X[I] \leftrightarrow X[I + H]$ ;
    end;
  end;
end;

```

Magic order merge-sort procedure: $MOS[N]$

```

procedure  $MOS[N]$ 
do
   $m \leftarrow \lceil \log N \rceil - 1$ ;
   $j \leftarrow m$ ;
  while  $j \geq 0$  do
     $h \leftarrow 2^j$ ;
    for  $0 \leq I < N - h$  do
       $CI[I, j, 0, h]$ ;
    end;
     $k \leftarrow m$ ;
    while  $k > j$  do
       $h \leftarrow 2^k - 2^j$ ;
      for  $0 \leq I < N - h$  do
         $CI[I, j, 1, h]$ ;
      end;
       $k \leftarrow k - 1$ ;
    end;
     $j \leftarrow j - 1$ ;
  end;
end.

```

II. The Precision of the Algorithm

As the external characteristics are guaranteed in [1], we give a simple explanation of the relationship between this algorithm and the biquadratic numbers linked merge algorithm. Let these be two 2^{n-1} cascade connected sorted data arrays, respectively merged, one using the biquadratic linked merge algorithm and the other by magic order merge algorithm. Let the data array using the former algorithm be designated X , and the latter by $\mathcal{A}$,

then the elements of the two arrays in comparison/exchange after each pass may have a corresponding relationship as shown in Figure 3.

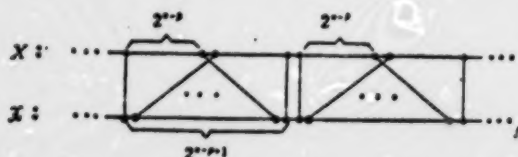


Figure 3. The Corresponding Relationship of the Two Data Arrays After the P-th Pass

The figure shows that after the P-th pass processing, the elements on $\mathcal{A}$, divided into a series of segments of length (2^{n-p+1}) , have a one-to-one correspondence with the 2^{n-p} elements in the similar distance under the mixed interpretation.

When the two merged data arrays have different lengths, i.e., $N_1 \geq N_2$, then the magic order merge format requires it to add to the second data array elements such that N_2 will be equal to N_1 or $N_1 - 1$.

The sorting is achieved by repeatedly merging subarrays, and after merging, the subarrays are still interleaved in $\mathcal{A}$. The number of the sorted subarrays will decrease by one-half after each merge. After n merges on the arrays, the array elements will be sequentially arranged. Consequently, from the fact that it is not necessary to augment the initialized operation, it can be said that the processing format is unified.

III. Parametric Analysis

Comparison frequency $C[N]$

Let $C[j, k, N]$ be the N elements, at the k -th merge, the j -th pass processing comparison frequency number is

$$C[N] = \sum_{k=1}^n \sum_{j=1}^k C[j, k, N] \quad (1)$$

as the first pass differs from the remaining passes, then

$$C[N] = \sum_{k=1}^n C[1, k, N] + \sum_{k=1}^n \sum_{j=2}^k C[j, k, N]$$

In separately discussing the two values, for convenience, we use the following designations:

$$\begin{aligned} N(k) &= N(\bmod 2^{n-k}); \\ N(j, k) &= (N - h(j, k)) (\bmod 2^{n-k}); \end{aligned}$$

where $h(j, k)$ is the magic order value of the k -th merge and j -th pass processing, $h(1, k) = 2^{n-k}$, $h(j, k) = 2^{n-j+1} - 2^{n-k}$, $j \geq 2$

As

$$\delta_k = \left\lfloor \frac{N}{2^{n-k}} \right\rfloor \pmod{2};$$

$$\delta_{j,k} = \left\lfloor \frac{N - h(j, k)}{2^{n-k}} \right\rfloor \pmod{2};$$

then

$$C[1, k, N] = \left\lfloor \frac{N}{2^{n-k+1}} \right\rfloor \cdot 2^{n-k} + \delta_k \cdot N(k);$$

$$C[j, k, N] = \left\lfloor \frac{N - h(j, k)}{2^{n-k+1}} \right\rfloor \cdot 2^{n-k} + \delta_{j,k} \cdot N(j, k), \quad j \geq 2;$$

The parameter value can be obtained by substituting the above into (1).

In particular, when $N = 2$, $N(k) = N(j, k) = 0$, and

$$C[2^n] = \sum_{k=1}^n \left\lfloor \frac{2^n}{2^{n-k+1}} \right\rfloor \cdot 2^{n-k} + \sum_{k=2}^n \sum_{j=2}^k \left\lfloor \frac{2^n - 2^{n-j+1} + 2^{n-k}}{2^{n-k+1}} \right\rfloor \cdot 2^{n-k}$$

$$= \sum_{k=1}^n 2^{n-1} + \sum_{k=2}^n \sum_{j=2}^k (2^{n-1} - 2^{n-j})$$

$$= 2^{n-1} \cdot n \cdot (n-1) + 2^n - 1.$$

Comparison pass number $C_p[N]$

$$C_p[N] = \sum_{k=1}^n \sum_{j=1}^k 1 = \binom{n+1}{2} \quad (2)$$

Exchange frequency number $I[N]$

For each comparison, there is an accompanying exchange, so

$$I[N] \leq C[N] \quad (3)$$

Exchange pass number $I_p[N]$

$$I_p[N] = \binom{n+1}{2} \quad (4)$$

The different distance interval number $DIN[N]$

In order to determine its value, the characteristics of magic order is examined

$$\begin{cases} h(1, k) = 2^{n-k}, & 1 \leq k \leq n; \\ h(j, k) = 2^{n-j+1} - 2^{n-k}, & 2 \leq j \leq k \leq n; \end{cases}$$

Clearly, besides $h(1, k) = h(k, k)$, $2 \leq k \leq n$, the other values are all different, therefore,

$$DIN = \sum_{k=1}^n \sum_{j=1}^k 1 - \sum_{k=2}^n 1 = \binom{n}{2} + 1 \quad (5)$$

Transmission frequency $DT[N]$

$$DT[N] = C[N] + I[N] \quad (6)$$

Transmission pass number $DT_p[N]$

As the parameters and the support operation are related to the system structure, we utilize an equidistant interconnected model

$$DT_p[N] = \sum_{k=1}^n \sum_{j=1}^k 2 \cdot TS[j, k].$$

where $TS[j, k]$ is the transmission pass number, necessary distance to transmit $h(j, k)$. If the interconnected distance $\{2\}_{j=1}^{k-1}$, except for $h(1, k)$ can reach after the first pass, the others need two passes.

$$DT_p[N] = \sum_{k=1}^n 2 + \sum_{k=2}^n 3 + \sum_{k=2}^n \sum_{j=2}^k 4 = 2(n^2 - n + 1) \quad (7)$$

If the interconnected distance $\{h(j, k)\}_{j=1}^{k-1}$, then $TS[j, k] = 1$

$$DT_p[N] = \sum_{k=1}^n \sum_{j=1}^k 2 = n(n+1) \quad (8)$$

The influence of interconnected form on the computational speed can be seen from these parameters.

Auxiliary storage volume $AM[N]$

$$AM[N] = 0 \quad (9)$$

Auxiliary operation frequency $AON[N]$

Auxiliary computations: (1) computing h ; (2) $N-H$; (3) $1+H$; (4) $k-1$. (1), (2), and (4) need to be computed once, and (3) needs to be computed as many times as the comparisons. Since these are all arithmetic operations, then

$$AON[N] = \sum_{k=1}^n \sum_{j=1}^k 3 + C[N] = 3 \binom{n+1}{2} + C[N] \quad (10)$$

Since the controls require only logic decisions to form the sorting, then the complexities can be neglected.

Auxiliary operation pass number $AON_p[N]$

The processing of I+H can be concurrently done

$$AON_p[N] = 4 \cdot \binom{n+1}{2} \quad (11)$$

the operation time analysis is similar to that of (2).

The author has performed tens of millions of simulated computations on the 757 vector machine, and has actually carried out operations of this algorithm, through using sequence value and place value for description, and from this angle, successful reduction control complexities have been achieved.

This paper is part of the author's thesis, and he wishes to express his gratitude to Professors Gao Qinshi, Zheng Xiang, and Zhou Xaobe for guidance and assistance.

REFERENCES

1. Knuth, D.E., "The Art of Computer Programming," Vol 3 (Sorting and Searching), Addison-Wesley, Reading, MA, 1973, pp 111-113.
2. Lorin, H., "Sorting and Sort Systems," Addison-Wesley, Reading, MA, 1975, pp 358-365.
3. Zheng Zhijie, "The Duodirun Merging Algorithms (1) and (2), JISUANJI XUEBAO [CHINESE JOURNAL OF COMPUTERS], 6:2, 4 (1983).

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Luan Yumin [2940 3022 2404] (4).....	27-39
Luo Yinfang [5012 6892 5364] (6, 7; this is the only author who appears more than once in this list of articles.).....	54-62; 63-72
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Zheng Zhijie [6774 2535 2212] (20).....	209-215
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10 JULY 1986

CHINA REPORT

SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

SUCCESSSES, FAILURES IN CHINA'S ROCKET PROGRAM REVIEWED

Hong Kong TA-KUNG-PAO in Chinese 8 May 86 p 3

[Article in column "Canadian Airmail Dispatch" column by Fan Shihe [5400 1102 0678]: "Successes and Failures in China's Test-Launching of Rockets"]

[Text] On 30 April, the Imperial Bank of Canada held in Vancouver a conference on China's Seventh Five-Year Plan. Speakers at the conference included Fan Shihe, chief engineer of China's Ministry of Astronautics Industry. He gave a detailed briefing on recent developments in China's astronautics industry, which was rich in content and some of which had not been published before. Exerpts follow:

I am honored to be able to be here today to give a briefing on the developments in China's spaceflight technology and on the key points of its Seventh Five-Year Plan. I want to first give a general picture of developments in China's spaceflight technology.

General Picture of Developments in Spaceflight Technology

Based on the state's plan for development, at the end of the fifties China began the work of opening up and developing spaceflight technology. The corresponding research institutes, designing departments, experimental centers, factories, and launch sites were gradually set up. In the early stage, we developed sounding rockets and biological rockets. These rockets were propelled by liquid rocket engines or solid boosters.

After more than 10 years of hard work, in 1970 we successfully launched our first artificial satellite, which weighed 173 kilograms and was named the "East Is Red." The carrier used for this launch, named the "Long March No 1," was a three-stage rocket. The first and second stages had liquid propellant engines. The third stage was a solid rocket engine, for spin stabilization. The second "East Is Red" satellite was successfully launched in 1971. It was launched twice, both times successfully.

In 1974, the "Long March No 2" carrier was successfully developed. This was a two-stage liquid rocket. Its length was 31.7 meters, its maximum diameter 3.35 meters, its takeoff weight 191 tons, its low orbit carrying capacity 2 tons, and its orbital inclination 63 degrees. In November 1974, its first

test launch was a failure. Data obtained from its flight confirmed that a wire on the rate gyroscope had broken. For this reason, in later design and production we used reliable circuitry and quality control. From 1975 to the present, it has made a total of seven flights, all of them successful. During this time we have also obtained successes in satellite recovery technology. Therefore, we can see that the launch reliability of the Long March No 2 carrier rocket is very high.

The Technology of Launching Synchronous Satellites Has Already Been Mastered

In the seventies China developed a two-stage carrier rocket named "Storm No 1." It looked very much like the Long March No 1, but its systems were different from those of Long March No 2 to varying degrees. Also, "Storm No 1" did not have the good performance and reliability of Long March No 2, and therefore after 1981 its use was discontinued.

"Long March No 3" is China's new-type carrier rocket. It is a three-stage liquid rocket. The first and second stages were developed on the basis of the "Long March No 2." Its third stage has liquid hydrogen and liquid oxygen engines, and it possesses the capability of being able to be switched on twice. The third stage's maximum diameter is 2.25 meters, and the diameter of its cowl is 2.6 meters. The length of Long March No 3 is 43.25 meters, and its takeoff weight is 202 tons. When inclined at 31.1 degrees, it has a carrying capacity in synchronous transfer orbit of 1,400 kilograms.

Long March No 3 was first launched on 29 January 1984. Because of a breakdown in third-stage engines, this experimental launch was not completely successful. After the first launch, we quickly found the cause of the breakdown from the telemetric data obtained during it. We used 70 days' time to modify the hydrogen rocket engine. On 8 April 1984 there was a second launch, and satisfactory results were obtained. The rocket was then used for experiments on putting a communications satellite into synchronous transfer orbit. On 16 April of the same year, the satellite was accurately positioned in space above the equator at 125 degrees east longitude. This satellite is still working today.

Following this, on 1 February 1986 a practical communications and broadcasting satellite was successfully put into synchronous transfer orbit, and on 9 February it was accurately positioned in space above the equator at 103 degrees longitude. The successful launching of "Long March No 3" proves that its design plan is correct and that it is of reliable quality. The highly difficult technology of launching a synchronous satellite has already been mastered by our country's experts and engineers.

Launching for Foreign Countries Welcomed

Up to now, our country has used its own carrier rockets at its own launch bases to launch 18 types of satellites developed by itself (including scientific sounding satellites, technical experiment satellites, and communication and broadcasting satellites). We will hereafter launch in succession our country's practical synchronous communications and broadcasting satellites, weather satellites, and scientific experiment satellites.

Next I will talk about the key points in the development of spaceflight technology in the Seventh Five-Year Plan period.

Based on our country's practical needs, we will in succession put the "Long March No 3" and "Long March No 4" into service for our country's consumers. At the same time, based on our country's open-door policy, we have decided to provide "Long March No 2" and "Long March No 3" for use in international commercial launches. We welcome foreign consumers who use satellites for peaceful purposes to entrust us with the carrier launch. "Long March No 2" has a very good success rate. We intend to further improve the performance of Long March No 2. There is a high degree of consistency in the design, technology, quality control, as well as systems engineering management in our country's Long March series.

To further satisfy the needs of consumers, our country will further improve the "Long March No 3" carrier vehicle, so that it has a carrying capacity of more than two tons when in synchronous transfer orbit. We will modify its control system so that it has the capability to adapt to orbit changes. At the same time, to launch heavier synchronous satellites, we will add a booster to the I class, so that the Long March carrier vehicle becomes an integrated system.

The satellite is also one of our country's key development projects. In the Seventh Five-Year Plan period, first we will develop communications and broadcasting satellites with large capacities. The satellites will have a triaxial stabilizing, double-unit element unified drive system program. Second, synchronous weather satellites and earth resources satellites can be used for weather forecasting, natural resources prospecting, and soil data surveys as well as environmental monitoring. Third, to meet the needs of consumers, we will develop a large number of ground stations with small diameter antennas in order to develop our country's communications and broadcasting undertakings.

The above are the main points in our country's development of spaceflight technology in the Seventh Five-Year Plan period.

Providing Good Service

To put into effect the open-door policy and carry out international cooperation is our country's national policy. On the basis of acting independently and keeping the initiative in our own hands, being self-reliant, equality and mutual benefit, and mutual trust, we will carry out exchanges and cooperate with spaceflight circles of various countries in the world. Provided the two sides have the need and the possibility, we will introduce technologies, introduce equipment, make extensive use of the strong points of various countries, and strive to raise the scientific and technical level, the administrative and management level, of our country's spaceflights. In the past several years we have signed spaceflight scientific and technical agreements with four countries in Western Europe--West Germany, France, Britain, and Italy--and we are now holding cooperation talks or signing agreements with some other countries on the European, Asian, and American continents.

Canada is a developed country, and its spaceflight technology is advanced. We hope China and Canada will henceforth be able to initiate various forms of cooperation. Our country has already decided to give play to its own superiority in spaceflight technology by putting its carrier rockets on the international market and by contracting to provide services in the development and launching of carrier rockets for the satellites of various countries. At the same time, we are willing to initiate various forms of cooperation with foreign countries in launch, measurement and control technologies.

The reasons that we are carrying out international cooperation and providing launching services are:

First, our preferential prices are lower than the preferential prices on the international market.

Second, at each stage of the launching service, we will provide good service to the greatest degree possible.

Third, we provide insurance. The China People's Insurance Corporation is willing to provide preferential insurance for any project proposed by a customer.

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CSO: 4008/63

NATIONAL DEVELOPMENTS

XI'AN JIAOTONG UNIVERSITY CALLED MAJOR SCIENCE BASE

Beijing RENMIN RIBAO in Chinese 7 Apr 86 p 1

[Article: "Xi'an Jiaotong University Has Taken Root in the Northwest, in 30 Years Becoming Its Major Educational and Scientific Research Base; Over 31,000 Graduates Have Been Trained and 570-plus Scientific Research Gains Achieved in the Past 15 Years"]

[Text] Correspondent Jiang Hanzhen [5592 5496 4631] reports that Xi'an Jiaotong University, which was begun in Shanghai in 1956 and then relocated inland, has now passed its 30th year. It has already taken root in the Great Northwest and become one of the major northern bases for training senior technologists and fostering scientific research.

To meet the needs of socialist economic construction and development in China, and to change the past irrational distribution of institutions of higher education in China, in 1956 the State Council decided to move Jiaotong University to Xi'an to help with socialist economic construction in the interior. At that time Premier Zhou Enlai personally took charge of the task, and he told the teachers and students that "The Chinese revolution originated in the Southeast and came to fruition in the Northwest. Construction in the Northwest must be aided by industrially and technologically advanced coastal areas." Premier Zhou hoped that the intellectuals at Jiaotong University would pluck up the courage "to ride a while on the back of a tiger," brave the storm, and face the world to move the great tree, which had grown for 60 years in Shanghai, to the Northwest, there to root it deeply in the fertile Northwestern soil.

Fired by Premier Zhou's enthusiasm, several established professors quickly straightened out property that had to remain behind in Shanghai, abandoned the good life and working conditions of Shanghai, and packed their wives and children off to Xi'an. Thirty years ago living conditions in Xi'an were rather difficult and food and necessities all had to be brought in from Shanghai. They uttered not a word of complaint, but wholeheartedly carried out their teaching duties and ensured that there was no drop in educational standards after the school was relocated to Xi'an. By 1958 most of the faculty had arrived in Xi'an, including 43 professors and 22 assistant professors. Thirty years ago, Professor Zhong Zhaolin [6988 0340 3829], now 86, was an activist in the campus relocation. He is now in a Shanghai

hospital for rest and recuperation. Professor Zhong is constantly mindful that he is a "Northwesterner" and he communicates periodically with the school. When he is well again he desires to return to the Northwest to work. Former Dean Peng Kang [1756 1660], who led the campus relocation at that time, and some well-known former professors devoted the second half of their lives to the Great Northwest and have long graced Xi'an's cemetery for revolutionary martyrs. The young students at Jiaotong University were even more prone to think of "transfer to the Great Northwest" as everybody's highest ideal: when the orders came there were no foot-draggers. Thirty years have passed, and second generation students at Jiaotong University have already married and embarked on their careers, while the third generation has become a true "little Shaanxi."

While assisting the Great Northwest, Jiaotong University has also achieved its own growth. At the time of relocation Xi'an Jiaotong University was a college of engineering, featuring 4 departments and 15 specialties. Now it has developed into a combined science and engineering-liberal arts university, emphasizing engineering, with 18 departments and 46 specialties. From 700-plus teachers at the time of relocation, the school has grown to more than 1,800 teachers, including 600-plus professors and assistant professors. In the 30 years since relocation the university has trained over 31,000 graduates--4 times as many as in the 53 years prior to the founding of the PRC--and one-third of these have been assigned in the Great Northwest. During the Sixth Five-year Plan, universities under all branches of the central government trained 12,000 college students for Shaanxi, and 20 percent of these were trained at Xi'an Jiaotong University. Now the technological backbone of some large northwestern enterprises, such as Lanzhou Refinery, Lanzhou Petroleum Machinery Plant, and Xi'an Electric Power Machinery Company, is composed of students trained at post-relocation Jiaotong University.

In the past 15 years the school has garnered 577 achievements in scientific research, of which 88 reach or approach international research standards, 2 earned National Natural Science Awards, and 10 won National Invention Awards. Economic benefits from existing scientific research achievements approach 500 million yuan, of which one-fifth goes to relevant factories, mines, and other enterprises in Shaanxi.

The educational base in the Great Northwest is rather weak, and after Xi'an Jiaotong University moved there it played an exemplary role in developing northwestern higher education facilities. It signed a long-term cooperation agreement with schools of higher education in the minority nationality region, helping those schools to improve their standards rapidly. In the past few years, it has trained 400-plus English teachers for institutions of higher learning in the northwestern region. Right now there are, altogether, 43 doctorates offered at the 40-plus institution of higher education in Shaanxi, and Xi'an Jiaotong University accounts for 19 of them. This school has become Shaanxi's primary forum for launching academic exchanges with the outside.

In the past 30 years the people of Shaanxi have shown zealous concern for Xi'an Jiaotong University, and in difficult times millet from Yan'an and vermicelli and white bread from the central Shaanxi plain have fed its teachers and students. Many times the people's government of Shaanxi has

organized efforts to transport prawns and fresh fish back from coastal areas to give comrades from the South a taste of seafood. As for the school's capital construction, Shaanxi spared no effort and completed the task in short order.

When Jiaotong University moved west, some comrades worried about whether relocation policy formulated by the central authorities was correct. At the time, comrade Chen Yi [7115 3015], mayor of Shanghai, said: "The verdict on relocating Jiaotong University will come after 10 years." Thirty years of experience amply illustrates that the relocation of Xi'an Jiaotong University has been a successful model for China in readjusting the strategic distribution of institutions of higher learning. The construction and growth of Xi'an Jiaotong University has far-ranging significance for development in the Great Northwest.

12510

CSO: 4008/2100

10 July 1986

NATIONAL DEVELOPMENTS

CHINA UNIVERSITY OF S&T REPORTS 60 PROMOTIONS

Beijing RENMIN RIBAO (Overseas Edition) in Chinese 13 Mar 86 p 3

[Article: "At China University of Science and Technology Commendation Is Based on Talent Alone: 60 Younger Teachers Are Promoted to Professor and Assistant Professor"]

[Text] According to a report in ZHONGGUO QINGNIAN BAO, "China University of Science and Technology is well-run and boasts plenty of young talent." In the wake of this praise, proffered by comrade Deng Xiaoping in 1984, China University of Science and Technology further eradicated the outworn concept of rank ordering based on seniority, persisted in considering academic standards, and emphasized practical contributions. Recently it also boldly promoted 60 younger teachers to the ranks of professor and assistant professor, a move which evoked strong reverberations among instructors and students at the school.

Among these 60 individuals, 6 instructors under the age of 45 were promoted to professor and 47 were promoted to assistant professor, while an additional 7 younger teachers under the age of 40 were promoted to assistant professor. Five of this latter group hold doctorates earned in Chinese universities. They have studied diligently, are imbued with the spirit of initiative, are constantly updating their knowledge, and have become the school's young academic leaders.

Chen Lin [7115 7207], who skipped a rank and was promoted to professor, is only 40. Altogether, since 1976 Chen has published over 20 insightful articles. In 1980, when he was a visiting student in the United States, his original concept of visual topology and functional layers was appraised very highly by associates from many nations in the fields of psychology, neuroscience, and computer visualization. He has been called the world's "first person to combine visual perception with topology."

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10 July 1986

NATIONAL DEVELOPMENTS

LU JIAXI DISCUSSES NEED FOR S&T COORDINATION

Beijing GUANGMING RIBAO in Chinese 2 Apr 86 p 2

[Article by Li Shuxi [2621 2885 0823] and Zhai Huisheng [5049 1920 3932]: "Lu Jiaxi [4151 0857 6932], Member of the CPPCC Standing Committee Discusses Building Up the Main Force of Science and Technology Through Coordination"]

[Text] When reporters met with Lu Jiaxi [4151 0857 6932], member of the CPPCC standing committee and president of the Chinese Academy of Sciences, he immediately began to discuss reform in the system of scientific and technological organization and problems in coordination.

He said that when comrade Yao Bang talked about thousands and thousands of soldiers and horses climbing the mountain to pick peaches, he evoked a vivid image. However, there cannot be only one road up the mountain. If many thousands of soldiers and horses are crowded onto a single road many will be trampled; if there is only one kind of peaches to pick the great army will be unable to exercise its function. Supposing that people have not carefully planted a variety of peaches in advance, this army of men and mounts cannot make its best effort. Therefore, we must recognize "diversity of form on all sides."

Lu Jiaxi has visited abroad on several occasions recently. What he saw and heard there made it even clearer to him that scientific and technological development strategy, and reform in the system of scientific and technological organization, must be geared to the needs of the four modernizations, the world at large, and future ideology. He said that while abroad he heard people saying that there must be the three "co's": coordination, cooperation, and collaboration. Coordination is comprehensive: rational vertical and horizontal relationships are established and scientific and technological administration must weave these into a network. There are many "scientific" organizations and units in China, and particularly those at the first level of central government should divide the work and cooperate with one another. Right now there is too much duplicate labor: one is doing the same thing another is doing, and sometimes the two are kept secret from each other. There is no surfeit of talent and funding in the first place, so duplication is a great waste, bringing half the result with twice the effort. We should consider the situation as a whole and then make certain choices. There are also many problems in cooperation: there are frequent disputes over trifles,

to the extent that good works are often left in a terrible mess. Herein lie problems in administrative systems and in ideological and political training.

Lu Jiaxi extracted from his bundle of papers the report made by Premier Zhao concerning the Seventh Five-year Plan, and told reporters that the system of scientific and technological organization must be reformed to serve economic construction. First of all we must concentrate on resolving major current research problems in production and construction. Previously we have devoted insufficient attention to this area, and hereafter we must greatly enhance our efforts. But even this is not enough: science and technology must precede production and construction. We must consider the economic construction and services of tomorrow, and we must think about laying the scientific foundation and providing technological guarantees for sustained, stable economic growth through the next 10 years and the 1st 50 years of the 21st century. Deng Xiaoping has pointed out that education must be geared to modernization, to the world at large, and to the future. This demand also applies absolutely to scientific research. In achieving this goal the crucial issue is still one of talent: how to stimulate initiative among scientific and technical personnel, and how to build up the main talent force. This is strategic, for it takes 100 years to build a generation of good men! The main talent issue is to assign people according to their aptitude. People have different talents: some people are clever (theoretical thinking comes easily) and some are deft (testing skills are strong); some people are good at "quick battles" (resolving short-term, ordinary, straightforward problems) and some can fight a "protracted war" (systematically resolving major problems). So long as it benefits the country and the people, we should encourage them to go all out in their work. Of course we must take all factors into consideration in overall planning and make suitable arrangements so that the appropriate quantity and quality of talent is present in all areas of basic research, applied research, and development. We must be adept at nurturing, discovering, and organizing scientific research forces, and we must take particular care to give those persons engaged in primary exploratory research and education the opportunity to participate in high-level research and teaching activities. We must be capable of interchange and permit people to change their occupations. At home and abroad there are a number of well-known scientists and scholars who have shifted occupations, and there is nothing wrong with this. Our current arbitrary uniformity and overcentralization disadvantage people in the exercise of subjective initiative.

Finally, Lu Jiaxi said that talent depends a person's own diligence, as well as on training and policy; diligence creates an opportunity for him to display his talent. "I have had a long career in teaching. I often say that if a teacher cannot train a number of students to be better than himself then he should be deposed." At that point, Lu Jiaxi laughed and said: "I have many students who have made outstanding contributions in their respective fields of scientific research and a few students who are now in Beijing attending the national CPPCC and NPC meetings, among them Xiamen University President Tian Zhaowu [3944 2507 2976]. There is a group of students who have surpassed me, so it looks like this particular teacher will not be deposed."

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CSO: 4008/2100

NATIONAL DEVELOPMENTS

S&T SERVICE TO FOUR MODERNIZATIONS DISCUSSED

Beijing GUANGMING RIBAO in Chinese 2 Apr 86 p 2

[Article by Wu Qinying [2936 0530 5391]: "How the Ranks of Science and Technology Can Serve the Four Modernizations Is Discussed by Wang Daheng [3769 1129 3801], NPC Deputy and Chinese Academy of Sciences Academic Department Member"]

[Text] Professor Wang Daheng [3769 1129 3801] is currently a deputy director of the Second Technical Sciences Department of the Chinese Academy of Sciences, and the honorary director of the Changchun Optics and Fine Mechanics Institute. In February and March of 1986, through an investigation of the implementation of scientific funding in the Chinese Academy of Sciences, Wang became deeply convinced that the issue of scientific and technical personnel serving the four modernizations is extremely important. He discussed his views with reporters:

I. It Is Well Worthwhile To Gear Scientific Research Toward Production

Professor Wang Daheng said an example of this kind is that the Military Academy of Medical Science used genetic engineering techniques to fabricate, at an advanced international level, an engineered vaccine for swine dysentery. They mixed this vaccine into fodder and fed it to sows, and the surviving swine possessed immunocompetence against yellow and white dysentery. According to calculations, if this success was extended throughout the country 1.5 billion yuan would be gained per year. Professor Wang said that many scientific and technical personnel are now engaged, under crude and simple conditions, in research on the key problems that urgently need to be solved, and number of high-level achievements have been made. There is, for example, Qinghua University's "new welding arc control technique," which has brought welding automation and achieved major economic results. Another example is the "Land Utilization Chart" drawn up by tens of units and hundreds of scientific workers nationwide, organized by the Chinese Academy of Sciences. It has provided an important basis for district planning and land development in China.

II. Qualified Scientists and Technicians Must Suit the Needs of Scientific Socialization

Wang Daheng said that nowadays a major scientific research project more often than not requires mutual cooperation between tens of units and as many as a hundred experts engaged in mutual interdepartmental and inter-unit cooperation. This requires scientific and technical personnel both to be strictly imbued with scientific character and to have the capacity for horizontal alliances featuring mutual interchange and cooperation. Wang Daheng is very cognizant of the qualities of scientific and technical personnel, and he says that if one cannot easily cooperate with others, then one cannot suit the needs of scientific socialization. We need experts who can take charge, and, what's more, we need experts who are well-connected in society as a whole and in scientific and technological relationships.

III. Give Gifted Members of the Scientific Community a Role To Play

Wang Daheng emphasized that there are a number of Academic Department members in the Chinese Academy of Sciences who are rare talents in the scientific community. We must give these people a role in important issues of scientific and technological development and economic construction. For example, important scientific projects and major construction projects must all be subjected to the arguments of experts. Through these people we can organize a multitude of forces and link up with talented people in various areas. The Academic Department members enjoy high prestige, command universal respect, have a wealth of experience, and possess profound knowledge. In addition, a large number of them have left their administrative posts. If we can give them a greater role to play we can reduce errors in construction and promote smooth construction in the four modernizations.

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CSO:4008/2100

HORIZONTAL RESEARCH, PRODUCTION ALLIANCES URGED

Beijing GUANGMING RIBAO in Chinese 30 Mar 86 p 1

[Commentary by Yu Weidong [0060 4850 2767] under the rubric "Weekly Commentary": "Develop Horizontal Research and Production Alliances"]

[Text] Modernized production is socialized production built upon a foundation of advanced science and technology. It is characterized by daily, intimate cooperation and integration between research and production. Cooperation between research and production is not something we have just acquired: since the founding of the PRC, the 156 projects in the 1950's and the "2 Missiles, 1 Satellite Project" of the 1960's were successful examples of large-scale cooperation between research and production. However, this cooperation was brought about by administrative means; it might be called a tree-like construction. In the 1980's cooperation between research and production in China has taken on the new form of horizontal alliance. The horizontal alliance is characterized by unchanging ownership and subordinate relationships among member units, the use of economic leverage, and conformity to the principles of voluntary participation, equality, and mutual benefit. It considers the development of new products, techniques, and technology--or technological reform--to be its objective. The alliance is a new coalition connected by economic ties; one could say it is a network-like construction. According to incomplete statistics, as of the end of 1985 there were over 10,000 allied research and production organizations of all kinds nationwide, of which 2,000-plus were in Shanghai and 1,200-plus were in Hebei. Horizontal research and production alliances occur in the following forms:

As to distinguishing the degree of intimacy in these alliances, we can divide them into two types: the loose alliance and the substantive alliance. The loose alliance binds a research unit and a production unit through a project contract and they jointly develop new products or new techniques. When the project contract is completed the alliance will have completed its mission as well. Consequently, this is a temporary, low-level form of alliance. In the substantive alliance, the two parties or the various parties in the alliance take part in joint capital or collaboration and organize themselves into an economic entity that operates jointly and divides profits. This form of horizontal alliance is also called an economic association. For example, Dalian Economic Association for Producing Textile Printing and Dyeing is made up of 16 units, including schools of higher education, research units, and enterprises. It achieves the full course of complementary research and

production: sample analysis, synthesis of raw materials, manufacturing of auxiliary textile chemicals, reeling and spinning of raw silk from cocoons, weaving, and dyeing. In 2 years time this economic association has come out with 90 new textile products.

As for distinguishing the substance of the alliances, we can divide them into the following types: alliances for industrial development, enterprise transformation, new product manufacturing, digestion of imported technology, new technological development, achievement transfer, project contracting, and multipurpose use of natural resources.

As to distinguishing the scope of allied member units, we can differentiate between two types: domestic alliances and international alliances. Domestic alliances can be further divided into the urban form (including alliances between research and production units within one city, and alliances that cut across regions, provinces, cities, and departments) and the integrated urban-rural form. In the wake of China's open door policy there has also been new growth in international research and production alliances. For example, Shanghai Materia Medica Institute of the Chinese Academy of Sciences and Japan's Comprehensive Medicinal Plant Testing Association allied to develop the new antineoplastic drug "AT-2153," and Shanghai Silicate Institute and Shanghai Xinyu Power Plant allied with the American Energy Conversion Device Company to develop the noncrystalline silicone solar cell. These are both examples of development through international alliances.

As far as distinguishing the allied member units is concerned, we can divide these into two-unit types (a research unit and a production unit or an institution of higher education and a production unit) and multi-unit types (research unit, institution of higher education, and production unit).

In the past few years horizontal alliances between research and production have expanded rapidly. They are just now unfolding, and are demonstrating great vitality. Their primary functions are as follows:

1. They have promoted technological progress in enterprises, particularly in medium-sized and small enterprises and township enterprises, they have stimulated a number of small factories, and they have brought clear economic results.
2. They have spurred research units and institutions of higher education to be more attuned to economic construction. Moreover, these units have increased receipts, enhanced self-development capabilities, improved research and education standards, and been advantageous in training new talented personnel who integrate theory with practice.
3. They have advanced intelligent and rational circulation, and have been helpful in allowing existing talent to exercise its role. Horizontal alliances between research and production do not change the subordinate relationships of personnel. They have enabled a great many scientists and technicians to go beyond the tall buildings and spacious courtyards of the research institutes and schools of higher learning, enter the front lines of production, and display their skills in medium-sized and small enterprises and

township enterprises. They go gladly, of their own free will, and this is something that was impossible to attain in the past under purely administrative means.

We must further develop alliances between research and production, and we must also resolve the following issues:

1. We must establish and perfect pertinent laws and regulations, safeguard the legal rights and interests of the allied parties, and ensure healthy development in research and production alliances. Right now, some scientific and technical departments report that the contracts signed frequently will not hold up; by contrast, production units report that some scientific and technical achievements are not ready yet, thus causing the production units to sustain losses.

2. We must resolve policy and organization problems. How can we give the appropriate support to public finances, tax revenues, and banking? We still lack a comprehensive set of policies. For example, intermediate testing is the link in transforming research achievements into industrialized production, but under the existing system of organization research units and enterprises alike find it a difficult problem to tackle. We must reform the system of organization now in effect, clear out funding channels, and create appropriate social conditions for the growth of research and production alliances.

3. We must enhance theoretical research. Horizontal alliances between research and production are based on commercialization of technical research achievements. However, in China we still do very little theoretical research on commercialization of scientific research gains. We understand very little about the specific properties of technical merchandise, or about the law of value as it concerns these goods. This leads to price confusion and very uneven remuneration in the technological marketplace. Many new problems arise out of this, and we need to have a proper theory to guide us in resolving them.

The growth of horizontal alliances between research and production is required for modernized production, for a socialist commodity economy, and for rapid forward development in research facilities. The extensive development of horizontal links is in itself a challenge to the original disjointed situation; it is a powerful assault on the old system of organization. In a sense one could say that the process of converting the old system to the new system of organization is precisely this process of eradicating the disjointed situation and extensively developing horizontal economic links, including horizontal links between research and production. Therefore, the development of horizontal alliances between research and production is extremely important for promoting economic restructuring in China's urban and rural areas, and also for promoting reforms in the system of scientific and technological organization and the system of education. We must enthusiastically foster and support this effort and point it toward a new stage of extensive and healthy development.

12510
CSO: 4008/2100

NATIONAL DEVELOPMENTS

JIANGXI RURAL TECHNOLOGY MARKET RESULTS REPORTED

Beijing NONGMIN RIBAO in Chinese 18 Mar 86 p 1

[Article: "Jiangxi Is Quickly Guiding Science and Technology Toward the Countryside, Obtaining Outstanding Results from the Rural Technology Market; 62.57 Million Yuan Worth of Composite Social and Economic Benefits Were Created in 1985, About 20 times the Amount of Scientific and Technological Investment"]

[Text] In order to guide science and technology toward the countryside, Jiangxi's Science Commission began in 1984 to establish a provincewide rural technology market. At present it has grown to encompass 98 counties (or administrative areas), accounting for 88 percent of all Jiangxi counties (or administrative areas). In 1985, 62.57 million yuan worth of composite social and economic benefits were created, about 20 times the amount of scientific and technological investment.

All over Jiangxi the core of the technology market is the county, which connects above to the province and region and below to townships and villages. Each market utilizes a combination of administrative means and economic leverage to enlist the services of talented people from social and scientific research units and institutions of higher education. They collect technology and vitalize rural economic services by organizing technological service teams and technological training, and by establishing economic associations between technology and production. For example, Longnan County Science and Technology Market called together over 60 scientists, technicians, and skillful craftsmen and organized 7 technological service teams, each with a different specialty, to go out into the countryside. Of these, the Technological Service Team To Transform Low-yield Orchards had 33 members, and they signed service contracts on nearly 30,000 fruit trees grown by 332 fruit-farming households. That year, through technological reforms--pruning, cultivation, fertilization, insect eradication, and disease treatment--the per-mu yield in Chinese chestnut orchards increased 50 percent over the previous year, and the per-mu yield in citrus orchards rose 130 percent. In Ganzhou Prefecture the technology market conducted a technical training class on pond milkfish breeding, and more than 3,200 people attended the class. After the students left the class they set off a surge of enthusiasm for raising pond milkfish. In 1985, 2.4 million-plus jin of milkfish were harvested throughout the prefecture. A collective of only four or five people set up shop as the

Ningdu County Chalk Factory and suggested the trial manufacture of dust-free chalk. However, they lacked the technology, funding, and equipment for the job. Ningdu County Technology Market sent out technical personnel, invested 13,000 yuan, and entered into joint operation with this plant to develop the product. Now this plant has grown into a new-style small enterprise employing 47 people. Its product sells well in Ruijin, Yudu, and other counties, and has also broken into the market in Nanchang, Shanghai, and other regions. In 9 months of 1985, this plant reached a production value of 95,000 yuan and achieved a net profit of 25,000 yuan. According to statistics, in 1985 Jiangxi's rural technology market launched 40,690 technological service projects (or instances) of all sorts, trained more than 15,000 youth, established 112 technical economic associations of various kinds, and imported and transferred 373 technical items.

In order to enhance guidance of rural technology markets and arrange coordinated efforts, the Jiangxi provincial government has formulated provisional methods for managing technology markets, and they have also recently approved the establishment of a provincial technological market development center.

12510

CSO: 4008/2100

NATIONAL DEVELOPMENTS

MORE TECHNOLOGY IMPORTS FOR MACHINE BUILDING INDUSTRY

OW291907 Beijing XINHUA in English 1757 GMT 29 May 86

[Text] Beijing, May 29 (XINHUA)--China is to import another 800 items of technology to revamp its machine building industry with foreign funds to be absorbed in the next five years.

This was disclosed by He Guangyuan, vice-minister of machine building industry, at today's national conference on machine building industry, which undertakes an important task of providing equipment for petroleum, coal, chemistry, electricity and textiles industries.

Priorities for technical import will be given to large and high-capacity equipment, such as mining, petrochemical, and energy-saving projects and those for producing export goods, the vice-minister said.

The industry will also make big efforts to attract more foreign investors, he said. It will first go into a group of 28 enterprises in cooperation with foreign partners in the form of joint venture, co-management and sole foreign investment in the next five years, which concern high technology and their products are export-oriented.

Besides, negotiations are under way on some projects between foreign businessmen and China's localities.

China's machine building industry will also make use of foreign loans in building and renovating 16 projects, including the projects of the Shanghai Machine Tool Plant and the Wuhan Heavy Machine Tool Plant.

According to the ministry, China imported 800 items of technology between 1978 and 1985, and now 47 percent of them have gone into production and 33 percent produced sample products.

By technical import and technological development, the machine building industry will stress upgrading its existing enterprises to manufacture complete sets of equipment of energy, transport, raw materials, and instruments and meters.

--In the fields of electricity generating and high-voltage transmission and transforming equipment, the industry will revamp four power centers of Beijing, Shanghai, Harbin, and Sichuan, and two transmission equipment producing centers in Xi'an and Liaoning. The industry will have an annual capacity of producing 10 million-kilowatt generating equipment by 1990.

--On the iron and steel industry, the industry will upgrade six heavy machinery plants in Shanghai, Shenyang and elsewhere in China.

--For the automotive industry, China will build some motor vehicle producing centers in Beijing, Changchun, Nanjing, Shanghai, and other areas. The annual output of motor vehicles will reach 700,000 in 1990.

--The production of equipment and machinery for open-cut coal mines, off-shore oil development, plastic processing and farming machines will also be expanded.

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CSO: 4010/59

NATIONAL DEVELOPMENTS

RETURNED STUDENTS ACHIEVEMENTS, ROLE IN RESEARCH NOTED

Beijing RENMIN RIBAO (Overseas Edition) in Chinese 21 Apr 86 p 4

[Text] In order to build up a highly qualified teaching force, the China University of Science and Technology has in the past few years sent 600 people including 310 teachers to 18 countries for advanced studies. Now 183 have returned after completing their studies abroad, and they are playing a prominent role as teachers and in scientific research.

According to a KEXUEBAO report, the students sent abroad by this university generally have done fairly well. Wang Zhaozhong [3769 5128 0022], who was sent to the 11th University of Paris, France, in 1979, discovered a new phase change in the conducting material three magnetization tantalum, which is known as one of the world's 10 discoveries in that field. Wu Zhongchao [0702 1813 6389], while studying at Cambridge University, England, won third place in the 1985 treatise awards sponsored by the International Foundation for Gravitational Studies. Cao Xiren [2580 1585 0088], while studying at Harvard University in the United States, won an award for outstanding student theses in America and had 13 highly regarded academic treatises published in influential U.S. magazines. The 183 returned teachers wrote a total of more than 600 treatises while abroad, more than 400 of which were of fairly high standards and published in international publications and journals. By their performance abroad, they could be divided roughly into three groups, with 40 percent of them in group A, 53 percent in group B, and 7 percent in group C. Based on the university's requirements, they generally took some new courses to strengthen their theoretical and professional knowledge. In research work, they made full use of the advanced laboratory and technological conditions abroad. Thus they have greatly enhanced their knowledge and training in both theoretical and technological fields and laid a good foundation for work after their return.

The teachers began to return to China one after another at the end of 1980. Most of them have played a backbone role in work, and many have become academic leaders. They impart the new technology and knowledge they have acquired from abroad in class and research work to the welcome of teachers and students.

According to incomplete statistics, they have opened nearly 100 new courses and run more than 20 discussion and research classes of various types. More than 60 of the 183 returned teachers are serving as tutors for students working

toward a master's degree, and 70 percent of them are teaching while doing research work. Since their return, they have published more than 400 academic papers; obtained approval or submitted report on 87 research projects including major research projects and projects financed by scientific foundations, which account for 53 percent of the total number of similar projects undertaken by the university as a whole; and produced results on 34 research projects, 6 of which won major achievement awards. Most of them have become academic or administrative leaders; 13 have been promoted to professors; 70 have become associate professors; and 47 have become the number one men at various levels, including 31 department heads.

12802/12859

CSO: 4008/2107

NATIONAL DEVELOPMENTS

CONTINUED SUPPORT OF TECHNOLOGY MARKET URGED

Beijing GUANGMING RIBAO in Chinese 7 Apr 86 p 1

[Article by staff commentator: "We Must Continue To Give Vigorous Support to the Technology Market"]

[Text] A year ago, we said that the appearance of the technology market is an objective requirement of the developing socialist commodity production in China, an inevitable product of the commercialization of science and technology. Practice in the past year has borne out that since the publication of the party Central Committee's decision on the reform of the science and technology management system, it has been the technology market that acts most promptly and produces the greatest impact. As a link between technology and economics and a bridge for scientific and technological achievements to be popularized and applied in the field of material production, the technology market has taken root firmly in China and has born rich fruits.

The situation is good as a whole. There are more than 5,000 technology trade organizations in the country, and their actually completed trade volume was 2.3 billion yuan in 1985, more than three times that in 1984. The technology trade is becoming increasingly extensive in scope, rich in content, and varied in forms. It has also been further strengthened in organization and management. Every province, municipality and autonomous region has set up its own organization dealing in technological commodities. More than 3,000 technology fairs of various forms were held in the past year. Technology trade has developed from transfers of single technological achievements and general technical services to technical training, technological job contracting, offers of technology as shares in joint ventures, joint development of new products and so forth. A large number of advanced and applicable technologies have been well received by small and medium-sized enterprises and town and township enterprises. Some items originally planned to be imported from abroad are now being obtained from the technology market through competitive bidding.

The results are obvious. The development of the technology market has promoted cooperation between scientists and producers, increased the ability of scientific research units to develop on their own, brought new vitality to the town and township enterprises and given scientists and technicians room to put their abilities and talents to use.

The technology market has unclogged the channels for scientific and technological achievements to flow into production so that they can be turned more quickly into real productive forces. The transfer rate of scientific and technological achievements in Shanghai in 1985 was double that in 1981, and more than 40 universities and colleges earned a net income of 80 million yuan last year from trade in technology. Through the technology market, a great deal of technology has found its way into the countryside, giving a very great impetus to rural economic development. Lingchuan County, Shanxi, had long been dependent on state financial subsidies, and then it became possible for the county to bring in technology, trained people and funds from the technology market. In 1985, the output value of the county's rural enterprises broke the 100 million yuan mark.

All this tells us that the development of the technology market is a major event in the history of the development of science and technology in China, and that it is playing an important role in propelling China's scientific, technological and economic growth.

The development of the technology market is a policy decision of the party Central Committee, and it is a completely new thing. However, precisely because it is still in the early period of development and lacks experience, it is unavoidable that problems of one kind or another will occur. It will be easy to go back to where we were before, but there is no hope in so doing. The correct attitude can only be to strengthen our confidence and actively support the technology market, analyzing, studying and properly guiding it, so that it will keep improving. The activities of the science and technology management system, the technological development institutions and the intermediary organizations in technological transfers, technological consultations, technological services, technological training and so forth must not be confused with the unhealthy trends in party and government organizations and among party and government cadres like using one's position and power to seek personal gain and feathering one's nest at public expense in doing business and running enterprises. At present, it seems that we still must adhere to the principle of "relaxation, flexibility, support and guidance" in developing the technological market. When we stress the need to draw distinctions in accordance with the party's policies, pay attention to legislative work, strengthen management of the technology market, attach importance to the development of complete sets of technologies, do a good job in the training of managerial personnel and so forth, our purpose is to implement this principle correctly.

The technology market is developing from small to big, from a lower to a higher level and from imperfect to more perfect. The burden is heavy and the road is long. The prospects are broad. We must still work hard.

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CSO: 4008/2107

NATIONAL DEVELOPMENTS

SHANGHAI CAS PROMOTES SCIENTIFIC COOPERATION

Beijing GUANGMING RIBAO in Chinese 7 Apr 86 p 1

[Article by staff reporter Huang Dongyuan [7806 0392 0337]]

[Text] In the course of the reform of the science and technology management system, the research institutes under the Shanghai branch of the Chinese Academy of Sciences have paid attention to bringing their superior technology and qualified people into play and actively developing high-level horizontal scientific and technological ties and cooperation in the form of partnerships between research and production, transfer of technological achievements, technological consultations and so forth. In the past few years, they have provided a number of urgently needed technological achievements for economic development and some new materials and products. Some of the products have found their way into international markets.

The high-level horizontal relations being developed by the research institutes of the Shanghai branch of the Chinese Academy of Sciences are mainly in the following three areas:

The first is to step up the work to develop new technologies. In the past few years, micro-electronics, optical fiber communications technology, genetic engineering and new materials have developed rapidly in China. Some research institutes have actively cooperated with related Shanghai factories in solving key technological problems. They have done a great deal of research work and achieved some results in the use of integrated circuits in Chinese-made video cassette recorders, color television sets, tape recorders and so forth. The Shanghai Metallurgy Institute, Shanghai Optics and Fine Mechanics Institute, Shanghai Communications Equipment Plant and Jiaotong University have worked in concert and successfully developed the terminal equipment and photoelectric components required in optical fiber communications. And they have now developed the capacity to produce 200 sets of various types of terminal equipment and several hundred sets of various kinds of photoelectric components.

The second is to cooperate with the large key enterprises. In 1984, The Shanghai Branch of the Chinese Academy of Sciences and the Shanghai Petrochemical General Plant signed a "scientific and technological cooperation agreement" to jointly tackle key technological problems and popularize research achievements. Up to the present, three of their technological achievements have been translated into fairly good economic results. The Shanghai

Metallurgy Institute has cooperated with the Shanghai Baoshan Iron and Steel Complex in conducting research on the corrosion of metals used in the Baoshan Iron and Steel Complex's water diversion works, and has provided the scientific basis for the iron and steel complex to use the Changjiang River's water for industrial purposes. According to calculations by experts concerned, this project has saved an investment of at least 50 million yuan for the state.

The third is to serve enterprises in importing, digesting and applying technology from abroad. They have cooperated with other units and successfully developed a number of new products and materials to substitute for imported products and materials. The Shanghai Organic Chemistry Institute has successfully developed an antifreeze liquid for motor vehicles, which had to be imported in the past. It is now produced in batches by a factory in Nantong, Jiangsu.

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NATIONAL DEVELOPMENTS

YOUNGER SCIENTISTS, TECHNICIANS PLAY LARGE ROLE AS INVENTORS

Beijing BEIJING KEJIBAO in Chinese 26 Mar 86 p 1

[Article by staff reporter Shi Wenjie [0670 2429 1240]]

[Text] On the eve of the first anniversary of the promulgation of China's Patent Law, this reporter learned from the Municipal Patent Bureau that up to now more than 60 inventions have been granted patents in the Beijing area. Among the scientists and technicians who have won patent rights, the overwhelming majority are people under 50. Young and middle-aged scientists and technicians are playing a major role as patent-winning inventors in Beijing.

These young and middle-aged inventors not only aspire to invent and create things as their goals in life, but link their own inventive and creative activities closely with the destiny of the motherland, the future of socialist modernization and the interests of the people. After 8 years of hard work and overcoming a number of difficulties, Ding Liping, a middle-aged scientist at the Iron and Steel Research Institute, and his colleagues finally developed a new type of drill solder with Chinese characteristics used in nuclear engineering. They were among the first group awarded patent rights by the State Patent Bureau and have received large orders totaling a million yuan, creating considerable economic benefit for the state. Hu Guohua, a middle-aged scientist, is doing optical research work for the Ministry of Astronautics. He and another scientist invented a variable optical filter artificial color indicator device, for which a patent was granted. It is a holographic and optical information processing and experiment system, and its invention has provided a new type of research tool for those engaged in optical studies.

Under the warmhearted guidance and help of older experts, Zhao Lei, a young scientist at the Beijing Industrial University, has grown up quickly. He won a first-class prize at the first Edison cup youth invention contest. A small four-way voltage stabilizer he had invented with a lot of hard work was granted a patent for exterior design. A pocket-size transistor on-line automatic testing instrument invented by him has been filed for patent.

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CSO: 4008/2107

NATIONAL DEVELOPMENTS

BRIEFS

SINO-FRENCH TECHNOLOGICAL, NUCLEAR ACCORD--Paris, May 23 (XINHUA)--China and France signed a four-year scientific and technological cooperation accord on agronomic research here today. The accord was signed by Lu Liangshu, president of the Chinese Academy of Agricultural Sciences, and Jacques Ploy, director of the French Institute for Agronomic Research. The accord proposes exchanges in the fields of soil microbiology, vegetable planting, rural economy, and improvement of wheat quality. A coordinating committee comprising representatives from both countries will meet every two years in China and France alternately to coordinate the exchanges. Meanwhile, China and France signed a letter of intent here this evening on the evaluations of nuclear safety in a nuclear power plant in Guangdong Province, China. The letter was signed by Jiang Shengjie, director of the National Bureau of Nuclear Safety of China, and Francois Cogne, director of the Nuclear Protection and Safety Institute of France. [Text] [Beijing XINHUA in English 1432 GMT 24 May 86 OW] /6091

ASSOCIATION SEEKS FOREIGN SCHOLARS--Beijing, June 3 (XINHUA)--The China Association for Science and Technology, a non-governmental organization, is trying hard to attract more foreign scholars to come to China for academic exchanges, PEOPLE'S DAILY reported today. In the past six years the association has organized more than 700 international symposiums in China and received more than 30,000 scholars from abroad, according to the paper. The symposiums have helped Chinese scientists know better about the latest developments in science and technology in other countries, the paper said. Meanwhile, the association has sent 3,000 members abroad to study, give lectures, do research or attend international symposiums. More than 200 Chinese scientists have been elected to leading posts of international organizations. [Text] [Beijing XINHUA in English 0759 GMT 3 Jun 86 OW] /6091

CSO: 4010/59

PHYSICAL SCIENCES

MOVING SHOT POINT METHOD AND DATA PROCESSING OF SEISMIC REFRACTION SURVEYS IN SHALLOW SEAS STUDIED

Qingdao SHANDONG HAIYANG XUEYUAN XUEBAO [JOURNAL OF SHANDONG COLLEGE OF OCEANOLOGY] in Chinese Vol 15, No 3, 15 Sep 85 pp 76-84

[Article by Yang Henai [2799 0735 0035], Department of Marine Geology: "The Study of Moving Shot Point Method and Data Processing of Seismic Refraction Surveys in Shallow Sea," paper received on 9 January 1985]

[Text] English Abstract: This paper is a brief summary of engineering geological survey with seismic refraction method over Hongdao, Shijiushuo and Lanshantou shallow water regions during 1976-78. It briefly presents the working method and the interpretation of data which were collected with float cable and continuous profiling in the study area.

Based on operations, the method of data processing and field procedure of seismic refraction method in shallow sea regions were further considered and a theoretical model was set up for data processing.

China's coastal waters are extensive, the sea bottom is rich in natural treasures, and the seacoast has excellent natural harbors. Studying the epigenetic geological structures of the sea bottom has become an important task for developing sea bottom epigenetic ore resources and developing marine engineering. There are mainly three methods of the basic geological surveys which are currently being carried out in the harbors: (1) the exploration drilling method: it can supply the most direct and most reliable geological materials and related technical engineering parameters and it is an indispensable method in marine engineering exploration. Its major shortcomings are: low efficiency, high investment, and it can only provide materials for the well site. (2) Shallow stratigraphic section instrument measurements: This is an advanced technique currently carried out in epigenetic measurement at sea. It is highly efficient, low cost, the materials are directly observed, the strata resolution is high, and it is a method which is widely used today. However, because the signal it emits is high frequency and its power is low, signal energy can decay very quickly in thick strata coarse friable deposits it is very limited in exploration depth. (3) Epigenetic seismic refraction surveys: This is a well-developed and effective exploration method for studying epigenetic geological structures. The energy of its excitation signal is high, frequency is low, exploration depth is deep, and matched with the above two methods it can supply more detailed geological

materials. In 1976-77, the Shandong College of Oceanology's geophysical prospecting adopted this method in harbor engineering geological surveys in planning for the Hongdao reservoir and the Qingdao iron works. Comparing the bedrock depth measured and the materials of many wells, the error was less than 5 percent and excellent geological results were obtained. However, compared to shallow stratigraphic section instrument measurements, its efficiency was low, costs were high and operation at sea was complex and these are the basic reasons why this method has not been widely adopted. In 1978 in selecting harbors on southern Shandong, we successfully tested the single ship continuous operating epigenetic seismic refraction method, raising work efficiency over 20-fold, lowering costs, providing basic depth contour plain view of Shijiuso and Lanshantou harbors which became basic materials for harbor selection and construction in southern Shandong.

This paper summarizes our experience of the past few years in using the epigenetic seismic refraction wave method for harbor engineering geological exploration, discusses the basic principles and observational system of the gas gun and analog or digital tape seismograph for carrying out the continuous operation refraction wave method at sea. In addition, it further presents the interpretation theory and digital processing methods use of moving shot point time interval curve made up of recordings of common [gong 0364] shot points and the theory concerning its procedures and design.

I. The Epigenetic Seismic Refraction Survey Method

A. Geological and Physical Conditions for Epigenetic Seismic Refraction Survey

The physical conditions of seismic refraction method are that the wave velocity in the refraction layer must be greater than the wave velocity in the overlying strata. On the basis of the geological profiles in the harbors we have surveyed, they can be divided basically into upper and lower parts, according to structural and physical analysis. The upper part is weathered crust of igneous rock and water-bearing open deposits of long standing made up of interbedded drift mud, mud, coarse sand, fine sand and silt of unequal thicknesses and in which the sonar wave velocity is between 1500 m/s and 1800 m/s. The lower part is firm igneous rock which has not yet been weathered and in which the sonar wave velocity is between 3000 m/s and 5000 m/s. It is clear that the unweathered igneous rock surface is a clear velocity boundary. Generally a basement stratum of dense structure and higher wave velocity can be found below the open water-bearing deposits. Thus, using the seismic refraction method for carrying out engineering geological surveys in harbors has the necessary geological and physical conditions.

B. Method of Operation at Sea

For the past few years, dynamite explosions have been used at sea as the seismic source with pressure sensitive and piezoelectric detectors receiving the shock information and a domestically manufactured model DZ-663 24 channel magnetic tape seismograph used for recording and reproducing monitor records. The distance between the channels is 10 m, the receiving earth section length is 230 m, and the overall length of the electric cable is 300 m. Two observation systems have been used.

1. The encounter time-interval curve observation system

This system requires that the cable be placed on the sea bottom on the line to be measured and the boats stopped. It requires four 12-30 hp boats to be used as instrument boat (command boat), orientation boat, and two blast boats, respectively. The efficiency of this observation system is low; it can only measure 1.5 km of profile per day, and it is subject to influences of water depth, sea currents, tides, and waves, and such problems that the cable which is placed on the sea bottom cannot be maintained in position along a straight line and thus the shot point positions are not correct.

2. The pursuit time-interval curve observation system

This observation system only requires one 60-hp boat. The instrument group, orientation group, and blast group are all on-board this boat, the detector and the cable are towed from the boat's stern and float at a depth of 7-9 m below the surface. The work is carried out continuously while the boat is traveling at a uniform speed (Fig. 1). While the boat travels along the measurement line at an even speed, an explosion is detonated at fixed time intervals (the time intervals are determined by the distance between shots, the boat's speed, and sea conditions) and at the same time a fix is made on the position of the seismic focus. To maintain a reliable tracking refraction profile, the distance between two shot points should be less than the arrangement length, generally about 150 m. If an airgun seismic focus is used, the distance between shots can be reduced to 30 m, which not only improves the work efficiency, but also more tracks can be realized in the same refraction surface section, thus improving the reliability of the material interpretation. In this way, nearly 1,000 records can be obtained in a day, requiring the use of a computer for digital processing and thus automation of the materials interpretation.

B. Method of materials interpretation

The interpretation of materials is mainly to determine, on the basis of the recorded materials, the normal depth of the refraction surface, the wave velocity in the refraction layer and, using some characteristics in the materials to determine the lithic changes and structural fault situation in the refraction layer.

1. Computing the wave velocity in the refraction layer

When using the encounter time-interval curve observation system, using the normal [zheng 2973] time-interval curve $t_1(x)$ and the reverse [fan 0646] time-interval curve $t_2(x)$, the differential interval curves $t(x)$ and the $t_0(x)$ curve can be determined by E. (1).

$$\left. \begin{aligned} t(x) &= t_1(x) + \Delta t(x) \\ t_0(x) &= t_1(x) - \Delta t(x) \end{aligned} \right\} \quad (1)$$

In the above equation, $\Delta t(x) = T - t_2(x)$, T represents the interchange time values at shot points 01 and 02 (Fig. 2).

Assuming the wave velocity V_1 in the refraction layer does not change, the pitch of the refraction layer is less than 15° , by conventional computation methods the wave velocity in the refraction layer can be computed using the approximation equation (2).

$$V_1 = 2 \frac{dx}{dt} \quad (2)$$

i.e., the wave velocity in the refraction layer is equal to three times the differential time-interval curve gradient reciprocal.

From Eq. (1) and Fig. 2 it can be seen that the normal time-interval curve of $t_1(x)$ is the time equation bisector of $t(x)$ and $t_0(x)$ and the time, the time at the shot points 01 and 02 are T_{01} and $2T - t_{02}$, respectively, the shot interval is L , thus the approximation equation for the wave velocity in the refraction layer can be written

$$V_1 = \frac{2L}{2T - (t_{01} + t_{02})} \quad (3)$$

When the pursuit time-interval observation system is in continuous operation, Eq. (3) can be used to compute the wave velocity V_1 in the refraction layer. L , T , t_{01} and t_{02} in the equation can be solved on the basis of the observation system and recordings.

2. Computing the normal line depth in the refraction layer

When the V_0 and V_1 in the received earth section and the boundary gradient does not change, the equation for computing the normal line depth is used

$$h(x) = \frac{V_0}{2\sqrt{1 - \left(\frac{V_0}{V_1}\right)^2}} t_0(x) \quad (4)$$

to find the normal line depth at point x . Here, V_0 is the wave velocity in the water and water bearing open depositional layer covering the basement, generally regarded as $V_0 = 1500 \text{ m/s}$, V_1 can be used to solve Eqs. (2) and (3), $t_0(x)$ can be found after drawing the time-interval curve.

3. Tide correction

At sea, seismic survey, seismic focus, and detectors are all submerged to a certain depth, thus the boundary normal line depth found at the seismic focus and reception point are influenced by the tides, and in epigenetic geological surveys, when using floating cable, it is necessary to correct for the tide. Since tidal action and the submerged depth of the seismic point and the

detector are different, the seismic focuses and detectors on a measurement line may not be at the same level. Since the submerged depth of the seismic focus and the detectors are different, the depth computed using Eq. (4) is normal line depth from the intermediate horizon surface between the seismic point and the detector to the refraction layer. Tidal action causes the height of the intermediate horizon surface to change with time. To eliminate tidal influence it is necessary to make a tidal correction of the computed depth. Thus, in harbor geological surveys, the tidal reference of zero depth is used to compute the depth H (Fig. 3).

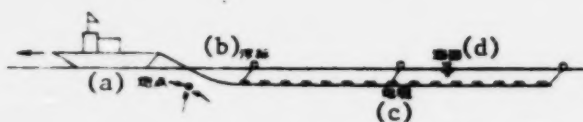


Figure 1. Diagram of Continuous Operation

Key:

- a. Shot point
- b. Floating marker
- c. Electric cable
- d. Sea surface

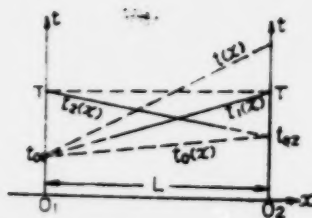


Figure 2. $t(x)$ and $t_0(x)$ Plotted According to $t_1(x)$ and $t_2(x)$

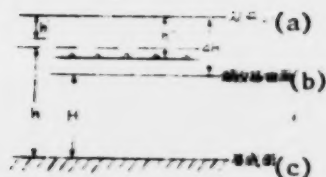


Figure 3. Diagram of Tide Correction

Key:

- a. Sea surface
- b. Basic tide surface
- c. Basement surface

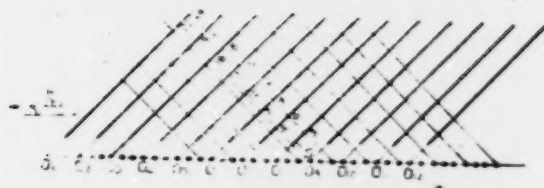


Figure 4. Continuous Pursuit Observation System

The tidal correction equation is

$$H = h - \Delta H + \frac{1}{2}(h' + h'') \quad (5)$$

in which ΔH is high tide, h' and h'' are the submerged depth of the seismic focus and the detectors, respectively.

II. Research on Principles of Moving Shot Point Method Interpretation and Data Processing

In using epigenetic seismic refraction method, carrying out epigenetic geological surveys accurately and at high speed is the key to further development of the refraction method. Based on the experience of operations at sea in the past few years, we recognize that using the single boat continuous operation method and using the moving shot point principles for automated data processing of the materials can greatly improve work efficiency and prospecting accuracy and can open new vistas for epigenetic refraction prospecting.

A. Observation system and method of creating the moving shot point time-interval curve

Since the velocity of the low speed layer at sea is known (1500 m/s), to improve efficiency in operations at sea, the detectors can avoid direct waves by being placed directly in the first arrival zone of the refraction waves. This demands that the horizontal distance x_0 from the first detector to the seismic focus satisfy the equation

$$x_0 \geq 2h \sqrt{\frac{V_1 + V_0}{V_1 - V_0}} \quad (6)$$

in which h is the maximum depth of the refraction layer, V_1 is the wave velocity in the refraction stratum, and V_0 is the wave velocity in the low speed layer 1500 m/s.

If we use 24 seismographs and an airgun as a seismic focus, with an interval of 10 m, the boat moving at an even speed of 1 m/s, and an excitation every 30 seconds, we will have continuous tracking observation. From the observation system (Fig. 4) we know that the first seismograph's eighth shot, the fourth seismograph's seventh shot, the seventh seismograph's sixth shot..., the 20-second seismograph's first shot, are at the same reception point S position (i.e., at the ninth shot point). On the basis of the positional relationship between the shot reception points as illustrated in Figure 4, we can find in the eight neighboring common shot point records the eight seismograph records at the same reception point (see Table 1). Using the principle of interchange, the refraction wave time information of these eight seismograph records can be plotted as a refraction wave moving shot point time-interval curve t_2 (Fig. 5). It forms an encounter time-interval curve with the time interval curve $t_1(x)$ of the first shot's common shot point record. Using Eq. (1) we find $t_0(x)$ and on using Eq. (4) compute the refraction layer normal line depth at the reception points.

B. Digital processing method and program design scheme

Digital processing of epigenetic refraction seismic surveys carries out discrete sampling of records obtained in the field, then inputs the sampling values into a computer and carries out the relevant arithmetic processing to determine the initial arrival time when the refraction waves reached each detector, and using the method of least squares finds such parameters as the intercept distance and slope of the refraction wave time-interval curve, computes the wave velocity in the refraction layer and the t_0 values at the reception points, then finally determines the normal line depth of the refraction layer at the reception points. Below we explain the computational method and program outline of the main program.

(b) 道号 \ 点位号 (a)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	...
(c) 点号																														
1		22	23	24																										
2		19	20	21	22	23	24																							
3		16	17	18	19	20	21	22	23	24																				
4		13	14	15	16	17	18	19	20	21	22	23	24																	
5		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24														
6		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24											
7		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24								
8		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24					
9			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
10				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22					
11					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19							
12						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16									
13							1	2	3	4	5	6	7	8	9	10	11	12	13											
14								1	2	3	4	5	6	7	8	9	10													
15									1	2	3	4	5	6	7															
...																														
...																														

Table 1. Channel Number Distribution Relationship of Neighboring 8 Shot Records at the Same Point Position

Key:

- a. Point position number
- b. Channel number
- c. Shot point number

1. Extracting the initial arrival time of the refraction wave

This processing is primarily accurately determining the initial arrival time of the refraction waves of each record on the profile to prepare the data for further digital processing. The processing program primarily includes: sending the initial value (such as the number of records on the profile and the initial value of the relevant control variables), inputting a record, preprocessing, finding the initial arrival time of each refraction wave, and storing it in a two-dimensional array $C(p,j)$, up until the records on a profile have all been input, then it enters the follow-up program (see Fig. 6).

Using the cross correlation function, the initial arrival time is computed, accurately measuring the time when the refraction wave arrived at each channel is the key problem to this method, digitally using the cross correlation function to describe quantitatively the relevant degree of two wave forms. It is measuring the degree of similarity of the two waveforms as well as a function of the time displacement between the two waveforms. The cross correlation function is at the maximum when there are only two waveforms overlapped in the process of time displacement change between two identical waveforms. Thus, by computing the cross correlation function, the time difference of the arrival of the refraction wave information at any two detectors can be found.

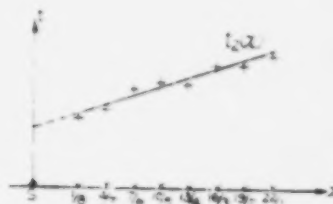
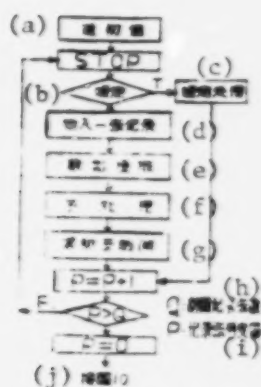


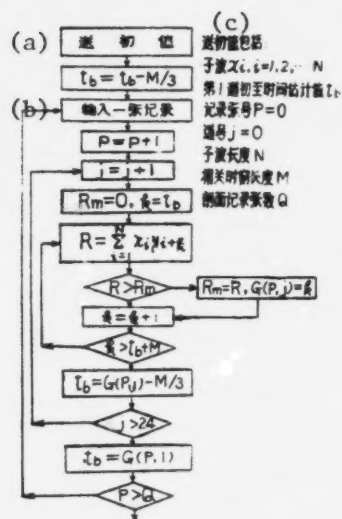
Figure 5. Moving Shot Point Time-Interval Curve



Key:

- a. Send initial value
- b. Dummy shot
- c. Dummy shot processing
- d. Input one record
- e. Number [unreadable] rearrangement
- f. Sub-processing
- g. Find initial arrival time
- h. Number of profile records
- i. Record number variable
- j. To Figure 10

Figure 6. Profile Pre-Processing Block Diagram



Key:

- a. Send initial value
- b. Input one record
- c. Send initial value includes:
 Wavelet $x_i, i=1, 2, \dots, N$
 First channel initial arrival time t_b
 Record number $P=0$
 Channel number $j=0$
 Wavelet length N
 Correlation time window length M
 Profile record number Q

Figure 7. Block Diagram for Using Cross Correlation to Find Initial Arrival Time on the Channels

If the refraction wave information received from the same source at two receptor channels are $x(t)$ and $y(t)$ respectively, then after discretization, the two groups of time sequences obtained are $(x_i), (y_i), i=0, 1, 2, \dots, N$, their correlation function is

$$R_{xy}(k) = \sum_{i=0}^N x_i y_{i+k} \quad (7)$$

when it constantly changes the k value, we can obtain the maximum value $R_{xy}(k_{max})$ of $R_{xy}(k)$, and k_{max} is the time difference of x_i, y_i . All we have to do is select the refraction wavelet and provide an initial arrival time, and by carrying out cross correlation computations of the information on the various detectors and within the time-wall of a certain length, and we can determine the initial arrival time when the refraction waves reached each channel. The program flowchart for computing the initial arrival time on the channels is illustrated in Figure 7.

2. Equation for finding the time-interval curve

Assuming the boundary inclination and the wave velocity do not change, the time t_i when the refraction wave arrives at each channel and the shot detection distance x_i are correlated linearly. In the rectangular coordinates with time as the longitudinal axis, and distance as the vertical axis, the

dot group (x_i, t_i) , $i=1,2,\dots,24$, reveals a linear distribution, its linear equation is $t=a+bx$, using the principles of least squares to select the coefficients a and b , its formula is

$$a = \frac{\left(\sum_{i=1}^n x_i^2\right)\left(\sum_{i=1}^n t_i\right) - \left(\sum_{i=1}^n x_i\right)\left(\sum_{i=1}^n x_i t_i\right)}{n\left(\sum_{i=1}^n x_i^2\right) - \left(\sum_{i=1}^n x_i\right)^2} \quad (8)$$

$$b = \frac{n\sum_{i=1}^n x_i t_i - \left(\sum_{i=1}^n x_i\right)\left(\sum_{i=1}^n t_i\right)}{n\left(\sum_{i=1}^n x_i^2\right) - \left(\sum_{i=1}^n x_i\right)^2} \quad (9)$$

a is the intercept distance of this time-interval curve, and corresponds to the time t_0 at the shot point. Using known data (x_i, t_i) , $i=1,2,\dots,24$, the program flowchart for finding the time-interval curve coefficients a and b is indicated in Figure 8.

3. Extracting moving shot point time-interval information

From Fig. 4 and Table 1 one can see that at the reception point after the ninth shot the refraction wave information of eight shots can be obtained, and a moving shot point time-interval curve can be made up and in addition, each additional shot can be obtained from the three moving shot point time-interval curves made up by the previous eight shot points. Under the conditions assumed previously, the distance x from each shot point to the reception point still exhibits a linear relationship with the refraction wave initial arrival time t , and the coefficients a and b of the moving shot point time-interval curve equation are determined according to Eqs. (8) and (9). The key is in extracting from the continuous 8 shot records the initial arrival time on the corresponding channel. Depending on the spatial distribution of the shot points and reception channels in continuous operation, the initial arrival times $G(p,j)$ are extracted using the common shot point records, then the initial arrival time information of the moving shot point records is extracted according to Block Diagram 9.

4. Calculating the wave velocity in the refraction layer and the normal line depth at the reception point

From Fig. 4 it can be seen that starting with the eighth shot, the first-third channel position of each shot record can form three moving shot time-interval curves from the time information of the previous 8 shots. With the time-interval curves of the previous seventh shot, they form three groups of encounter time-interval curves, and the distance of the two coordinates' point of origin is

$$L_n = 30 + (20 + n)\Delta x, \quad n = 1, 2, 3$$

(10)

In the equation, Δx is the channel interval (10 m). If after the eighth shot record is input, $n=1$, $L_{n=1}$ expresses the distance between the two coordinates' point of origin of the first encounter time-interval curve made up of the time interval curve $t_2(x)$ of the first shots common shot point records and the moving shot point time-interval curve $t_1(x)$ at the first channel position of the eighth shot (corresponding to the first shot's 22nd channel position), when $n=2$, $L_{n=2}$ expresses the distance between the two coordinates' point of origin of the second encounter time-interval curve made up of the first shot's time-interval curve and the moving shot point time-interval curve at the eighth shot's second channel position (corresponding to the first shot's 23rd channel position)...

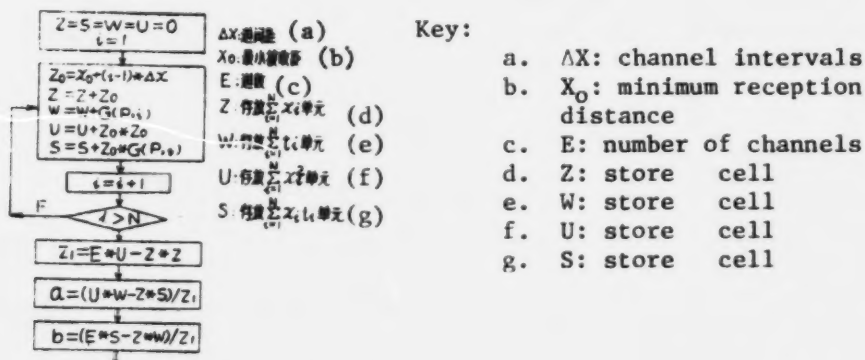


Figure 8. Block Diagram for Finding Coefficients a and b

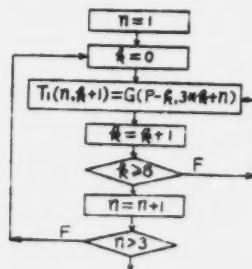


Figure 9. Block Diagram for Extracting Moving Shot Point Initial Arrival Time

Using the method of least squares we solve the coefficients of the two encounter time-interval curve equations. The time-interval curve equation is

$$t = a_{p-7} + b_{p-7} \cdot x \quad (11)$$

and the fan time-interval curve equation (i.e., the moving shot point time-interval curve equation) is

$$t_n = a'_n + b'_n \cdot x \quad (12)$$

in which a_{p-7} and b_{p-7} represent the time the Pth record is input and the seventh previous shot time-interval curve equation coefficient is solved after the P-7th record is input. a'_n and b'_n represent the n ($1 \leq n \leq 3$) moving shot point time-interval curve equation coefficient after the input of the Pth record, and can be calculated according to the block diagram in Figure 8, at this time $E=8$ and $\Delta x=30$ m.

(1) Finding wave velocity in refraction layer

Substituting $x=L_n$ in Eqs. (11) and (12) we find the average value of the time as the interchange time value T_n of the encounter time-interval curve, i.e.

$$T_n = \frac{(a'_n + a_{p-7} + b'_n + b_{p-7}) \cdot L_n}{2} \quad (13)$$

After solving for T_n , then using Eq. (3) we calculate the wave velocity $V_1(n)$ in the refraction layer, i.e.,

$$V_1(n) = \frac{2L_n}{2T_n - (a_{p-7} + a'_n)} \quad (14)$$

Take the average of the three velocities $V_1(n)$, $n=1,2,3$, found from the three encounter time-interval curves as the wave velocity in the refraction layer within the p-7 shot reception section, i.e.,

$$V_1(p-7) = \frac{1}{3} \sum_{n=1}^3 V_1(n) \quad (15)$$

(2) Find the normal line depth of the refraction layer at each reception point on the profile

Using Eq. (1) find the t_0 value of each reception point on the refraction layer normal line depth at each reception point found using the encounter time-interval curve. Suppose x_j is the shot detector distance of the j th channel on the normal time-interval curve, i.e., $x_j = 30 + (j-1)\Delta x$, $j=1, 2, \dots, 24$. In the equation, the number 30 is the minimum shot detector distance, i.e., $x_1 = 30$ m, Δx is the interval between channels (10 m).

After inputting the Pth record, calculate the formula for t_0 on the j channel position of the P-7th shot as

$$t_0 = a_p + b_p + x_j + T_n + (a'_n + b'_n(L_n - x_j)) \quad (16)$$

then substitute t_0 into Eq. (4) and calculate the boundary normal line depth at the j channel position.

In addition, it can also be seen in Figure 4 that the reception points after the ninth shot position have recorded the information of the previous 8 shots, and each shot also forms three encounter time-interval curves with the moving shot time-interval curves at channels 21-24, thus beginning with the 8th shot, on the previous three channels of each shot the depth is calculated 24, 23, and 22 times. On channel 21 before the 9th shot position, the depth of 1-3 channel position is calculated 3 times, on 4-6 channel positions, it is calculated 6 times...., and on the 19-21st channel positions it is calculated 21 times. Repeated calculations in this fashion improve the precision of depth calculations. In program design, a sequential number group $H_x(n)$ for each depth calculation point on the profile was created for storing the accumulated value of the depth values that have been repeatedly calculated then the average value of the depth is found depending on the number of accumulations as the final calculated depth. See Figures 10 and 11 for the block diagrams of the calculations.

Figure 11 is the final program block diagram for processing the profile materials. In the figure the dashed line diagram I, for the output profile processing result, to rearrange the accumulated depth values $H(p, j)$ of multiple calculations stored in the reception point positions using the shot point number and channel number in an earlier program into a uniform sequence n according to the reception points on the profile, and put them into the number group $H_x(n)$, $1 \leq n \leq QX3$.

The dashed line box II samples the average depth values of the accumulated depth values $H_x(n)$, $1 \leq n \leq 21$ of the 21 reception points between the second shot position and the ninth shot position according to the number of accumulations at the reception points and sends the calculation result back to the original position $H_x(n)$.

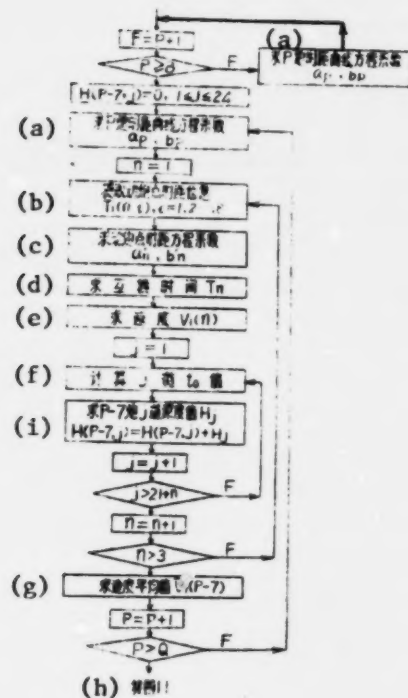


Figure 10. Block Diagram for Finding Velocity and Depth

Key:

- a. Find P shot time-interval equation coefficients a_p, b_p
- b. Extract moving shot point time-interval information
- c. Find moving shot point time-interval information
- d. Find interchange time T_n
- e. Find velocity $V_1(n)$
- f. Calculate t_0 value for channel j
- g. Find average value of velocity $V_1(P-7)$
- h. To Figure 11
- i. Find P-7 shot j channel depth H_j

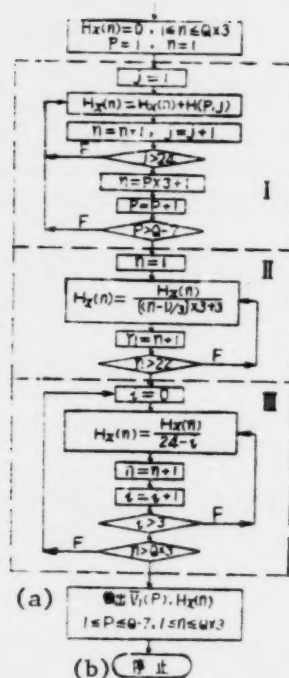


Figure 11. Output Velocity and Depth Block Diagram

Key:

- a. Output
- b. Stop

Dashed line III calculates the depth of the reception points ($n > 21$) after the ninth shot position on the profile. Because each three neighboring point positions have accumulations of 24, 23, and 22 depth calculation values, it is necessary to average the depth values of the number of actual accumulations, and then send it back to the original position $H_x(n)$, $21 < n \leq Qx3$.

After the depth values at all the reception points on the profile have been extracted, they are output according to the reception point sequence number n , and at the same time the velocity $\bar{V}_1(P)$, $1 \leq P \leq Q-7$ is output according to the shot point sequence number P . Depending on changes in the output values, the boundary depth and lateral changes in velocity can be understood and the structural state of the refraction layer along the profile can be further deduced, this concludes the profile processing. Similar processing can be carried out for other profiles, but due to differences in the measurement line length, the initial conditions at processing time are not the same.

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PHYSICAL SCIENCES

APPLICATION OF FAST HILBERT TRANSFORM CALCULATIONS TO INTERPRETATION OF TWO-DIMENSIONAL MAGNETIC ANOMALIES

Qingdao SHANDONG HAIYANG XUEYUAN XUEBAO [JOURNAL OF SHANDONG COLLEGE OF OCEANOLOGY] in Chinese Vol 15, No 3, 15 Sep 85 pp 67-75

[Article by Wang Shuoru [3762 4311 0320] and Yu Tao [0060 3447], Department of Marine Geology: "Fast Hilbert Transform Calculations and Their Application to the Interpretation of Two-Dimensional Magnetic Anomalies"; paper received 6 November 1984]

[Text] Abstract: Hilbert transform is a method for digital processing. This paper presents two types of Hilbert transform formulas and their calculation formulas in frequency domain based on Fourier transforms. Hilbert transform formulas of $\Delta\tilde{T}_1$ and $\Delta\tilde{T}_2$ of the total magnetic effect of some two-dimensional magnetic bodies are obtained according to the correlation of component magnetic effect. A new procedure for ΔT interpretation is developed using some special points and the intersection of $\Delta\tilde{T}_1$, $\Delta\tilde{T}_2$ and ΔT curves. The validity of the procedure is tested on theoretical models and a field example.

The basic task of gravity and magnetic [zhongci 6850 4318] data processing is to extract more information from observation data and by a method of enriching the interpretation of gravity and magnetic anomalies, to improve the accuracy and reliability of the results of geological interpretation. Hilbert transforms are a method of data processing which in recent years have been used in gravity and magnetic anomalies. Hilbert transforms have been used primarily in conversion [husuan 0062 4615][1]; and to reflect through some components and the Hilbert transform of a two-dimensional body's gravity and magnetic anomaly the essentials of hidden depth and occurrence[2,3]. Undoubtedly, these results have a definite practical significance. However, whether or not Hilbert transforms have a relationship only with place field component conversion needs to be further clarified. Next, what is obtained from magnetometry on the ocean surface is the total magnetic [zongci 4920 4318] anomaly ΔT , thus, what is even more practical is to use Hilbert transforms directly on ΔT to interpret the anomaly. From the practical angle, it is also very important to determine a simpler method of Hilbert transform. These three items are the main problems discussed in this paper.

I. Expression of Hilbert Transform

The definition of the Hilbert transform $\tilde{g}(x)$ of a function $g(x)$ is[4]

$$\tilde{g}(x) = \frac{1}{\pi} \int_{-\infty}^{\infty} \frac{g(\tau)}{x - \tau} d\tau . \quad (1)$$

Its contratransform is

$$g(x) = -\frac{1}{\pi} \int_{-\infty}^{\infty} \frac{\tilde{g}(\tau)}{x - \tau} d\tau . \quad (2)$$

The faltung form of Eq. (1) is written

$$\tilde{g}(x) = \frac{1}{\pi x} * g(x) .$$

Correspondingly

$$\tilde{G}(\omega) = H(\omega) \cdot G(\omega) \quad (3)$$

in which $\tilde{G}(\omega)$, $G(\omega)$ are the Fourier transforms of $\tilde{g}(x)$ and $g(x)$ respectively, and $H(\omega)$ is the frequency spectrum of $\frac{1}{\pi x}$.

If the Fourier transform is defined as

$$F(\omega) = \int_{-\infty}^{\infty} f(x) \cdot e^{-j\omega x} dx ,$$

because

$$H(\omega) = \begin{cases} -j & \omega > 0 \\ j & \omega < 0 \end{cases} ,$$

then Eq. (3) becomes

$$\bar{G}(\omega) = \begin{cases} -j \cdot G(\omega) & \omega > 0 \\ j \cdot G(\omega) & \omega < 0 \end{cases} \quad (4)$$

Let

$$G_1(\omega) = G_R(\omega) + j \cdot G_I(\omega) \quad (5)$$

then from Eq. (4) we can obtain

$$\bar{G}_1(\omega) = \begin{cases} G_I(\omega) - j \cdot G_R(\omega) & \omega > 0 \\ -G_I(\omega) + j \cdot G_R(\omega) & \omega < 0 \end{cases} \quad (6)$$

For the real function, the real part of its Fourier transform is the accidental function, and the imaginary part is the odd function. Therefore we should have

$$G_1(-\omega) = G_R(\omega) - j \cdot G_I(\omega) \quad (7)$$

The contra-Fourier transform of $\bar{G}_1(\omega)$ is

$$\begin{aligned} \bar{g}_1(x) &= \frac{1}{2\pi} \cdot \int_{-\infty}^{\infty} \bar{G}_1(\omega) \cdot G_1(\omega) \cdot e^{j\omega x} d\omega \\ &= \frac{1}{2\pi} \left[\int_{-\infty}^0 j \cdot G_I(\omega) \cdot e^{j\omega x} d\omega - \int_0^{\infty} j \cdot G_I(\omega) \cdot e^{j\omega x} d\omega \right] \\ &= \frac{1}{2\pi} \left[\int_0^{\infty} j \cdot G_I(-\omega) \cdot e^{-j\omega x} d\omega - \int_0^{\infty} j \cdot G_I(\omega) \cdot e^{j\omega x} d\omega \right] \end{aligned}$$

Substitution the two equations (5) and (7) and collating them we get

$$\bar{g}_1(x) = \frac{1}{\pi} \int_0^{\infty} (G_R(\omega) \cdot \sin \omega x + G_I(\omega) \cdot \cos \omega x) d\omega \quad (8)$$

If we let

$$G_2(\omega) = -G_R(\omega) + j \cdot G_I(\omega) \quad (9)$$

then based on Eq. (4), we should have

$$G_z(\omega) = \begin{cases} G_r(\omega) + j \cdot G_z(\omega) & \omega > 0 \\ -G_r(\omega) - j \cdot G_z(\omega) & \omega < 0 \end{cases} \quad (10)$$

The derivational process for Eq. (8) is similar and we can obtain the contra-transform of $\tilde{G}(\omega)$

$$\tilde{g}_z(x) = \frac{1}{\pi} \int_0^\infty [-G_r(\omega) \cdot \sin \omega x + G_r(\omega) \cdot \cos \omega x] d\omega \quad (11)$$

From this it can be seen that we can provide two different definitions of the Hilbert transform, i.e., Eq. (8) and Eq. (11) (to distinguish the two we will use different subscripts for the two transforms).

It has already been proven that for two dimensional space, the two equations (6) and (8) are the interrelationship of the orthogonal components in a single plane place field. The Hilbert transform $\Delta \tilde{H}_1(x)$ of the surface magnetic anomaly $\Delta H(x)$ is $\Delta Z(x)$, the Hilbert transform $\Delta \tilde{Z}_1(z)$ of the magnetic measurement $\Delta Z(z)$ in a straight hole corresponds to $\Delta H(z)$; but the contra-Hilbert transform of $\Delta Z(x)$ and $\Delta H(z)$ corresponds to $H(x)$ and $Z(z)$ [1].

II. The Hilbert Transforms $\Delta T_1(x)$ and $\Delta T_2(x)$ of the $\Delta T(x)$ of Some Regular Two-Dimensional Bodies

According to the definition of Hilbert transforms given above, we can find the Hilbert transform formula of two-dimensional total magnetic anomalies $\Delta T(x)$.

A. Method of finding Hilbert transform of $\Delta T(x)$

Since the $\Delta T(x)$ of horizontal columnar body corresponding to i_0 changes to $\Delta H(x)$; the $\Delta T(x)$ of a plate-shaped body corresponding to γ angle changes to the $\Delta H(x)$ when $(\gamma - i_0)$ is the angle. The i_0 here is the effective magnetization inclination; γ is the included angle of the magnetization direction and the plate surface; $\gamma = \alpha - i_0$ (α is the inclination of the plate). Therefore, according to $\Delta \tilde{H}_1(x) = \Delta Z(x)$, it is very easy to obtain $\Delta \tilde{T}_1(x)$.

According to the odd accident of Fourier transform, taking the even item sign reversal [oucixiang bianhao 0260 3945 7309 6239 5714] in $\Delta \tilde{T}_1(x)$ one can immediately obtain $\Delta \tilde{T}_2(x)$.

B. Hilbert transform expression of some regular two-dimensional bodies

According to the above method, it is not difficult to write the Hilbert transform equations of regular magnetic two-dimensional bodies.

1. Horizontal columnar body

$$\Delta T(x) = \frac{A}{(x^2 + h^2)^{3/2}} [-(h^2 - x^2) \cos(2i_0) - 2hx \sin(2i_0)] . \quad (12)$$

$$\Delta \bar{T}_1(x) = \frac{A}{(x^2 + h^2)^{3/2}} [(h^2 - x^2) \sin(2i_0) - 2hx \cos(2i_0)] . \quad (13)$$

$$\Delta \bar{T}_2(x) = \frac{A}{(x^2 + h^2)^{3/2}} [-(h^2 - x^2) \sin(2i_0) - 2hx \cos(2i_0)] . \quad (14)$$

2. Thin plate of infinite extension

$$\Delta T(x) = \frac{B}{x^2 + h^2} [-h \sin(\gamma - i_0) - x \cos(\gamma - i_0)] . \quad (15)$$

$$\Delta \bar{T}_1(x) = \frac{B}{x^2 + h^2} [h \cos(\gamma - i_0) - x \sin(\gamma - i_0)] . \quad (16)$$

$$\Delta \bar{T}_2(x) = \frac{B}{x^2 + h^2} [-h \cos(\gamma - i_0) - x \sin(\gamma - i_0)] . \quad (17)$$

3. Thick plate of infinite extension

$$\Delta T(x) = C \cdot \left[-\operatorname{tg}^{-1} \frac{2bh}{x^2 - b^2 + h^2} \sin(\gamma - i_0) + \frac{1}{2} \ln \frac{(x+b)^2 + h^2}{(x-b)^2 + h^2} \cos(\gamma - i_0) \right] . \quad (18)$$

$$\Delta \bar{T}_1(x) = C \cdot \left[\operatorname{tg}^{-1} \frac{2bh}{x^2 - b^2 + h^2} \cos(\gamma - i_0) + \frac{1}{2} \ln \frac{(x+b)^2 + h^2}{(x-b)^2 + h^2} \sin(\gamma - i_0) \right] . \quad (19)$$

$$\Delta \bar{T}_2(x) = C \cdot \left[-\operatorname{tg}^{-1} \frac{2bh}{x^2 - b^2 + h^2} \cos(\gamma - i_0) + \frac{1}{2} \ln \frac{(x+b)^2 + h^2}{(x-b)^2 + h^2} \sin(\gamma - i_0) \right] . \quad (20)$$

4. Horizontal thin plate

$$\Delta T(x) = A \cdot \frac{[-(h^2 + b^2 - x^2) \cos(2i_0) - 2hx \sin(2i_0)]}{[h^2 + (x+b)^2] \cdot [h^2 + (x-b)^2]} . \quad (21)$$

$$\Delta \bar{T}_1(x) = A \cdot \frac{[(h^2 + b^2 - x^2) \sin(2i_0) - 2hx \cos(2i_0)]}{[h^2 + (x+b)^2] \cdot [h^2 + (x-b)^2]} . \quad (22)$$

$$\Delta \bar{T}_2(x) = A \cdot \frac{[-(h^2 + b^2 - x^2) \sin(2i_0) - 2hx \cos(2i_0)]}{[h^2 + (x+b)^2] \cdot [h^2 + (x-b)^2]} . \quad (23)$$

5. Thin plate of finite extension

$$\Delta T(x) = B \cdot \left[\frac{-h_1 \sin(\gamma - i_0) - x \cos(\gamma - i_0)}{x^2 + h_1^2} + \frac{x \cos(\gamma - i_0) + h_2 \sin(\gamma - i_0)}{x^2 + h_2^2} \right] \quad (24)$$

$$\Delta \bar{T}_1(x) = B \cdot \left[\frac{h_1 \cos(\gamma - i_0) - x \sin(\gamma - i_0)}{x^2 + h_1^2} + \frac{x \sin(\gamma - i_0) - h_2 \cos(\gamma - i_0)}{x^2 + h_2^2} \right] \quad (25)$$

$$\Delta \bar{T}_2(x) = B \cdot \left[\frac{-h_1 \cos(\gamma - i_0) - x \sin(\gamma - i_0)}{x^2 + h_1^2} + \frac{x \sin(\gamma - i_0) + h_2 \cos(\gamma - i_0)}{x^2 + h_2^2} \right] \quad (26)$$

In which, A is the constant related to the intensity of magnetization; B is the constant related to the intensity of magnetization, plate width and plate inclination; C is the constant related to intensity of magnetization and plate inclination; b is the half-width of the plate; h_1 and h_2 are the thin plate top surface and bottom surface depth, respectively.

The horizontal columnar body and the plate body are representative two-dimensional bodies, and the two-dimensional body of any cross-section can be viewed as a combination of many plate bodies or many horizontal columnar bodies. Thus, the above relational expression in principle is also suited to any two-dimensional body.

III. A Simple and Fast Algorithm for Implementing the Hilbert Transform

Calculating the Hilbert transforms $\tilde{g}_1(x)$ and $\tilde{g}_2(x)$ of the function $g(x)$ can be carried out using the formulas (8) and (11), and their special functions $\tilde{G}_1(w)$ and $\tilde{G}_2(w)$ can also first be carried out according to formulas (6) and (10) and then the Fourier contratransform can be carried out to find $\tilde{g}_1(x)$ and $\tilde{g}_2(x)$. The second algorithm is simpler. The specific steps are as follows:

1. Use FFT to find the Fourier contratransform $G(x)$ of the original function $g(x)$.
2. Change the sign of the data of the real part $w > 0$ and the imaginary part $w < 0$ of $G(w)$ and then interchange the real and imaginary parts, to obtain $\tilde{G}_1(w)$; change the signs of the data of the real part and imaginary part of $w < 0$ of $G(w)$, then interchange the real part and the imaginary part to obtain $\tilde{G}_2(w)$.
3. Use FFT for the contra Fourier transforms, and after transform, $\tilde{g}_1(x)$ is obtained from $\tilde{G}_1(w)$ and $\tilde{g}_2(x)$ from $\tilde{G}_2(w)$.

IV. Applying Hilbert transforms Direct Inversion $\Delta T(x)$

On the basis of the intersecting coordinates of the three curves of $\Delta T(x)$, $\Delta \bar{T}_1(x)$ and $\Delta \bar{T}_2(x)$, the hidden depth and occurrence elements in some regular two-dimensional bodies can be inverted directly.

1. Horizontal columnar body

On the basis of the two Eqs. (13) and (14), letting $\Delta\tilde{T}_1(x) = \Delta\tilde{T}_2(x)$, we can get

$$h = \Delta x_{1,2}/2, \quad (27)$$

in which $\Delta x_{1,2}$ is the horizontal space of the intersection of $\Delta\tilde{T}_1(x)$ and $\Delta\tilde{T}_2(x)$.

Using $\Delta\tilde{T}_1(0)/\Delta T(0)$ (or $\Delta\tilde{T}_2(0)/\Delta T(0)$) we can get

$$i_0 = -\frac{1}{2} \operatorname{tg}^{-1} \frac{\Delta\tilde{T}_1(0)}{\Delta T(0)} \left(\text{或 } i_0 = -\frac{1}{2} \operatorname{tg}^{-1} \frac{\Delta\tilde{T}_2(0)}{\Delta T(0)} \right),$$

or

$$i_0 = \frac{1}{4} \left(\operatorname{tg}^{-1} \frac{\Delta\tilde{T}_2(0)}{\Delta T(0)} - \operatorname{tg}^{-1} \frac{\Delta\tilde{T}_1(0)}{\Delta T(0)} \right), \quad (28)$$

and

$$(\Delta T^2(0) + \Delta\tilde{T}_1^2(0))^{1/2} = A/h^2,$$

therefore

$$A = h^2 (\Delta\tilde{T}_1^2(0) + \Delta T^2(0))^{1/2}, \quad (29)$$

2. Thin plate of infinite extension

By the same principle, from $\Delta T(x) = \Delta\tilde{T}_2(x)$, we can get

$$h = x_0, \quad (30)$$

in which x_0 is the horizontal coordinate of $\Delta T(x)$ and $\Delta\tilde{T}_2(x)$.

From $\Delta T(x)/\Delta \tilde{T}_2(x)$ we can get

$$\gamma - i_0 = \operatorname{tg}^{-1} \frac{\Delta T(0)}{\Delta \tilde{T}_2(0)} \left(\text{或} - \operatorname{tg}^{-1} \frac{\Delta T(0)}{\Delta \tilde{T}_1(0)} \right). \quad (31)$$

and

$$B = h \cdot (\Delta T^2(0) + \Delta \tilde{T}_1^2(0))^{\frac{1}{2}}. \quad (32)$$

3. Thick plate of infinite extension

For Eq. (18) and Eq. (20) we derive, respectively

$$\begin{aligned} \Delta T'(x) &= C \cdot \left[\sin(\gamma - i_0) \left(\frac{-h}{(x+b)^2 + h^2} + \frac{h}{(x-b)^2 + h^2} \right) \right. \\ &\quad \left. + \cos(\gamma - i_0) \left(\frac{x+b}{(x+b)^2 + h^2} - \frac{x-b}{(x-b)^2 + h^2} \right) \right], \\ \Delta \tilde{T}'_2(x) &= C \cdot \left[\cos(\gamma - i_0) \left(\frac{-h}{(x+b)^2 + h^2} + \frac{h}{(x-b)^2 + h^2} \right) \right. \\ &\quad \left. + \sin(\gamma - i_0) \left(\frac{x+b}{(x+b)^2 + h^2} - \frac{x-b}{(x-b)^2 + h^2} \right) \right]. \end{aligned}$$

Letting $\Delta T'(x) = \Delta \tilde{T}'_2(x)$, we can obtain the following equation:

$$x^2 + 2hx - h^2 - b^2 = 0$$

solution, $x_{1,2} = -h \pm \sqrt{2h^2 - b^2}$.

From this we can solve

$$h = -(x_1 + x_2)/2. \quad (33)$$

$$b = \left[\frac{(x_1 - x_2)^2 - 2(x_1 + x_2)^2}{4} \right]^{1/2}. \quad (34)$$

In which x_1 and x_2 are the horizontal coordinates of the two intersecting points $\Delta T'(x)$ and $\Delta \tilde{T}'_2(x)$. Furthermore, we can easily solve

$$\gamma - i_0 = \operatorname{tg}^{-1} \frac{\Delta T(0)}{\Delta \tilde{T}_2(0)}. \quad (35)$$

$$C = -\frac{h^2 + b^2}{2b} (\Delta T'^2(0) + \Delta \tilde{T}_1'^2(0))^{1/4}, \quad (36)$$

4. Horizontal thin plate

From $\Delta \tilde{T}_1(x) = \Delta \tilde{T}_2(x)$ we get the solution $x_{1,2} = \pm(h^2 + b^2)^{1/2}$, thus the difference of the two roots

$$\Delta x_{12} = 2 \cdot (h^2 + b^2)^{1/2}. \quad (37)$$

from $\Delta T(x) = \Delta \tilde{T}_2(x)$, we get the solution $x_{1,2} = -h \pm (2h^2 + b^2)^{1/2}$, thus the difference of the two roots

$$\Delta x_{02} = 2 \cdot (2h^2 + b^2)^{1/2}. \quad (38)$$

From Eqs. (37) and (38) we can solve

$$h = (\Delta x_{02}^2 - \Delta x_{12}^2)^{1/2} / 2, \quad (39)$$

$$b = (2\Delta x_{12}^2 - \Delta x_{02}^2)^{1/2} / 2, \quad (40)$$

and, easily solve

$$i_0 = \frac{1}{2} \operatorname{tg} \frac{\Delta \tilde{T}_2(0)}{\Delta T(0)}. \quad (41)$$

$$A = (h^2 + b^2) \cdot (\Delta T^2(0) + \Delta \tilde{T}_1^2(0))^{1/4}, \quad (42)$$

5. Thin plate of finite extension

By the same method described above, letting $\Delta T(x) = \Delta \tilde{T}_2(x)$, $\Delta \tilde{T}_1(x) = \Delta \tilde{T}_2(x)$, it is not difficult to solve

$$h_1 = [(\Delta x_{0,2})^2 - \Delta x_{1,2}^2]^{1/2} - (\Delta x_{0,2}^2 - 2\Delta x_{1,2}^2)^{1/2} / 2, \quad (43)$$

$$h_2 = [(\Delta x_{0,2}^2 - \Delta x_{1,2}^2)^{1/2} + (\Delta x_{0,2}^2 - 2\Delta x_{1,2}^2)^{1/2}] / 2. \quad (44)$$

In which, $\Delta x_{0,2}$ and $\Delta x_{1,2}$ represent the horizontal space of the intersecting points of curves $\Delta T(x)$ and $\Delta \tilde{T}_2(x)$ and $\Delta \tilde{T}_1(x)$ and $\Delta \tilde{T}_2(x)$.

Furthermore, it is easy to solve

$$\gamma - i_0 = \operatorname{tg}^{-1} \frac{\Delta T(0)}{\Delta \tilde{T}_2(0)} . \quad (45)$$

$$B = \frac{h_1 h_2}{h_2 - h_1} (\Delta T^2(0) + \Delta \tilde{T}_1^2(0))^{1/4} . \quad (46)$$

It must be pointed out that the form of expression of the contraproblem solutions are not uniform. Solutions in other forms can be obtained depending on the other characteristic points of the curves.

As we said above, when applying the magnetic anomaly curve and its Hilbert transform curve for inversion, the starting point of the coordinates must be determined. Since $\Delta \tilde{T}_1(x) = -\Delta \tilde{T}_2(-x)$, it is most convenient to use this asymmetrical relationship to determine the starting point. The specific method is to first find the intersection o_1 and o_2 of the two curves $\Delta \tilde{T}_1(x)$ and $\Delta \tilde{T}_2(x)$, then the central point on the line segment $o_1 o_2$ is the coordinate starting point.

Another method for determining the starting point is to find the maximum value of $(\Delta T^2(x) + \Delta \tilde{T}_1^2(x))^{1/2}$, and the maximum value is the coordinate starting point. However, this method is rather troublesome. It should also be pointed out that the maximum value point of $[\Delta T^2(x) + \Delta \tilde{T}_2^2(x)]^{1/2}$ is not the coordinate starting point (this is because the signal² made up of $\Delta T + j\Delta \tilde{T}_2$ is not an analytical signal. In addition, this can also be seen directly from the theoretical form of regular bodies). Thus, N.L. Mohan and others used the method of determining the maximum value point by solving $(\Delta Z^2(x) + \Delta \tilde{Z}_2^2(x))^{1/2}$ [3] which is theoretically in error.

V. Theoretical Model and Examples

Using Hilbert transform, the authors made experimental calculations on two models: a horizontal columnar body and a horizontal thin plate, and found the inversion result and the carried out inversion interpretation of a field example.

Figures 1 and 2 are respectively the magnetic anomaly theoretical curve and the theoretical and calculation curve of its Hilbert transform on the above model when taking 64 sampling points. Tables 1 and 2 give the horizontal columnar body and horizontal thin plate model parameters and their inversion results.

From Tables 1 and 2 it can be seen that although the sampling number was small, the inversion precision was very high.

Figure 3 is a magnetic measurement profile of a place in Shandong. Actually, the ore body is a lens inclined toward the north, the downward length is smaller than the central submerged depth, it can be seen that it is nearly a horizontal columnar body[5]. On the basis of the above described interpretation method, using Figure 4 we found the inversion results: $h=30$ m, $i_0=39^\circ$. The interpretation results of authors of reference [5] who used the tangent method were: $h=413$ m, $i_0=48^\circ$. Number 2 test drilling found ore at 336 m. From this it can be seen that precision of this interpretation method is higher than the tangent method.

Table 1. Comparison of Horizontal Columnar Body Parameter Value Inversion Results

Model parameter	Theoretical value	Calculated Value		Error	
		64 dot sample	128 dot sample	64 dot sample	128 dot sample
h	200	186.9	197.5	7.55%	1.25%
i_0	30°	33.3°	30.5°	11.1%	1.8%
$A \times 10^7$	1.0	0.8314	0.9864	16.9%	1.36%

Table 2. Comparison of Horizontal Thin Plate Parameter Value Inversion Results

Model parameter	Theoretical value	Calculated Value		Error	
		64 dot sample	128 dot sample	64 dot sample	128 dot sample
h	110.0	114.2	108.9	3.8%	1.0%
b	59.0	61.0	57.0	3.39%	3.39%
i_0	78°	80.0°	79.0°	2.6%	1.3%
$A \times 10^7$	1.0	1.0726	0.9689	7.3%	3.1%

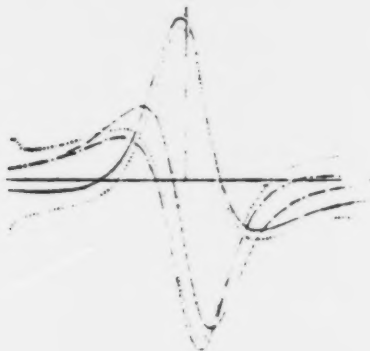


Figure 1. Theoretical and Calculated Curves of Horizontal Columnar Body

[Key on following page]

Key:

- | | |
|------------------|---|
| a. Dashed line | ΔT theoretical curve |
| b. Solid line | $\Delta \tilde{T}_1$ theoretical curve |
| c. Dot-dash line | $\Delta \tilde{T}_2$ theoretical curve |
| d. Circle line | calculated results of $\Delta \tilde{T}_1$ and $\Delta \tilde{T}_2$ |
| | Field value is any unit |

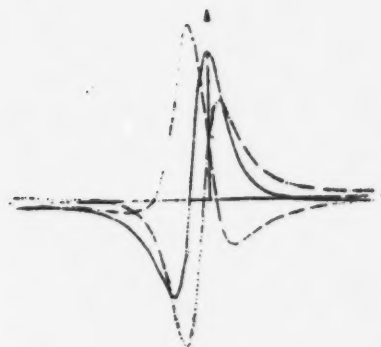


Figure 2. Theoretical and Calculated Curves of Horizontal Thin Plate Body

Key:

- | | |
|------------------|---|
| a. Dashed line | ΔT theoretical curve |
| b. Solid line | $\Delta \tilde{T}_1$ theoretical curve |
| c. Dot-dash line | $\Delta \tilde{T}_2$ theoretical curve |
| d. Circle line | calculated results of $\Delta \tilde{T}_1$ and $\Delta \tilde{T}_2$ |
| | Field value is any unit |

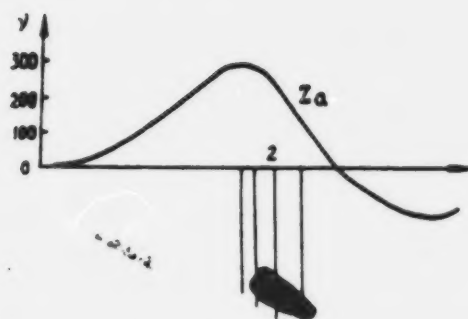


Figure 3. Profile of a Measured Magnetic Anomaly in Shandong

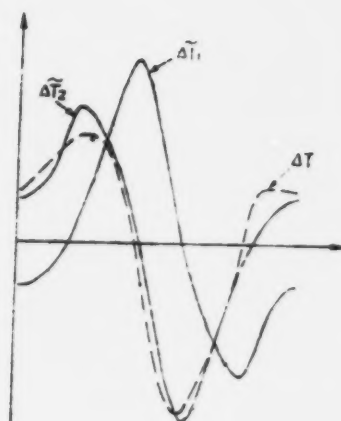


Figure 4. ΔT , $\Delta \tilde{T}_1$, $\Delta \tilde{T}_2$ Curves Calculated According to Measured Curves

Summarizing the above, since the inversion method presented in this paper uses the fast Hilbert transform method, it is simple and easy to use and is suited to applications in field conditions with a microcomputer.

REFERENCES

1. Wang Shuoru [3769 4311 0320], "A Two-dimensional Plane Component Husan in the Frequency Domain," Shandong HAIYANG XUEYUAN XUEBAO [JOURNAL OF THE SHANDONG COLLEGE OF OCEANOLOGY], No 4, 1984.
2. R. Green, "Using the Gravitational Method to Determine Precisely the Inclination of a Geological Contact Surface," GUOWAI WUTAN YIWENJI, Kexue Jishu Wenxian Chubanshe, 1978.
3. N.L. Mohan, N. Sundarajan and S.V. Seshagirirao, Interpretation of Some Two-dimensional Magnetic Bodies Using Hilbert Transform Geophysics, No 3, 1982.
4. Cheng Qiansheng [4453 0051 3932], XINHAO SHUZI CHULIDE SHUXUE YUANLI [MATHEMATICAL PRINCIPLES OF DIGITAL SIGNAL PROCESSING], Shiyou Gongye Chubanshe, 1979.
5. Liang Jinwen [2733 6930 2429], SHUIPING YUANZHUTI CI YICHANG DINGLIANG JIESHIDE JIANYI FANGFA [A SIMPLE METHOD OF HORIZONTAL COLUMNAR BODY MAGNETIC ANOMALY QUANTITATIVE INTERPRETATION], Dizhi Yu Kantan, No 11, 1980.

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PHYSICAL SCIENCES

INVERSION OF CIRCULANT MATRIX DISCUSSED

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[Text] Abstract: A method for finding the inverse of a circulant matrix is described and the representation of the inverse is presented.

I. Introduction

For cubic spline interpolation on $N + 1$ points, $x_0 < x_1 < x_2 < \dots < x_N$, with periodic boundary conditions, the following group of linear equations is derived [1]:

$$\begin{bmatrix} 2 & \mu_1 & 0 & \cdot & \cdot & \cdot & 0 & 0 & \lambda_1 \\ \lambda_1 & 2 & \mu_2 & \cdot & \cdot & \cdot & 0 & 0 & 0 \\ 0 & \lambda_1 & 2 & \cdot & \cdot & \cdot & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \ddots & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \ddots & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \ddots & \cdot & \cdot & \cdot \\ 0 & 0 & 0 & \cdot & \cdot & \cdot & 2 & \mu_{N-1} & 0 \\ 0 & 0 & 0 & \cdot & \cdot & \cdot & \lambda_{N-1} & 2 & \mu_{N-1} \\ \mu_N & 0 & 0 & \cdot & \cdot & \cdot & 0 & \lambda_N & 2 \end{bmatrix} \begin{Bmatrix} y'_1 \\ y'_2 \\ y'_3 \\ \cdot \\ \cdot \\ \cdot \\ y'_{N-1} \\ y'_{N-1} \\ y'_N \end{Bmatrix} = \begin{Bmatrix} q_1 \\ q_2 \\ q_3 \\ \cdot \\ \cdot \\ \cdot \\ q_{N-1} \\ q_{N-1} \\ q_N \end{Bmatrix} \quad (1.1)$$

Where $y'_1, y'_2, \dots, y'_N$ are the first derivatives at the interpolation points, and

$$\lambda_k = \frac{h_{k+1}}{h_k + h_{k+1}}, \quad \mu_k = 1 - \lambda_k \quad (k=1, 2, \dots, N-1)$$

$$\lambda_N = \frac{h_1}{h_N + h_1}, \quad \mu_N = 1 - \lambda_N, \quad h_k = x_k - x_{k-1} \quad (k=1, 2, \dots, N)$$

on the right side of equation (1.1),

$$q_k = 3\lambda_k \frac{y_k - y_{k-1}}{h_k} + 3\mu_k \frac{y_{k+1} - y_k}{h_{k+1}} \quad (k=1, 2, \dots, N)$$

where $y_k (k=1, 2, \dots, N)$, $y_{N+1} = y_1$ are the formula values at the interpolation points. Equation (1.1) can be solved by a method similar to "pursuit method" [1].

But for cubic spline interpolation on equidistant nodes with periodic boundary conditions, we derive the linearized algebraic equations

$$\begin{bmatrix} 4 & 1 & 0 & \dots & 0 & 0 & 1 \\ 1 & 4 & 1 & \dots & 0 & 0 & 0 \\ 0 & 1 & 4 & \dots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \dots & 4 & 1 & 0 \\ 0 & 0 & 0 & \dots & 1 & 4 & 1 \\ 1 & 0 & 0 & \dots & 0 & 1 & 4 \end{bmatrix} \begin{Bmatrix} y'_1 \\ y'_2 \\ y'_3 \\ \vdots \\ y'_{N-1} \\ y'_{N-1} \\ y'_N \end{Bmatrix} = \begin{Bmatrix} p_1 \\ p_2 \\ p_3 \\ \vdots \\ p_{N-1} \\ p_{N-1} \\ p_N \end{Bmatrix} \quad (1.2)$$

which we write

$$A\{X\} = \{P\}$$

where $\{X\} = (y'_1, y'_2, \dots, y'_N)^T$, $\{P\} = (p_1, p_2, \dots, p_N)^T$, and matrix A is a circulant matrix.

Below we discuss the method of inversion of the circulant matrix and give a formula for the inverse. Using the results, we can immediately obtain the inverse A^{-1} of matrix A in equation (1.2), which simplifies the process of solving this equation.

Structural calculations using circulant matrices have important applications; the inversion method given here for them is applicable to such calculations.

The discussion below is an extension of that in Ref. 2.

II. An Important Property of the Circulant Matrix

A partitioned matrix of order m ($m \geq 3$) can be represented as

$$A = (A_{uv}) \quad (u, v=0, 1, \dots, m-1)$$

where the submatrices A_{uv} are $n \times n$ square matrices. Accordingly, A is an $(m \times n) \times (m \times n)$ matrix.

If

$$A = \begin{bmatrix} A_0 & A_1 & A_2 & \dots & A_{m-1} \\ A_{m-1} & A_0 & A_1 & \dots & A_{m-2} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ A_1 & A_2 & A_3 & \dots & A_0 \end{bmatrix} \quad (2.1)$$

then we call A a circulant matrix.

The necessary and sufficient condition for A to be a circulant matrix [2]: when

$$k = \begin{cases} v-u & (v \geq u) \\ v-u+m & (v < u) \end{cases} \quad (2.2)$$

$A_k = A_{uv}$ of submatrices $A_k = A_{uv}$ ($u, v = 0, 1, \dots, m-1$; $k = 0, 1, \dots, m-1$) is the square matrices of $n \times n$, and m is the order of partitioned matrix A.

To discuss the characteristics of the circulant matrix we consider

$$\omega = \exp\left[\frac{2\pi}{m}\sqrt{-1}\right] = \exp\left[\frac{2\pi}{m}i\right]$$

which is an n -th root of unity. Let

$$\begin{aligned} \Omega_i &= \omega^i E_n / \sqrt{m} \\ &= \exp\left[\frac{2\pi i j}{m}\right] E_n / \sqrt{m} \quad (i, j = 0, 1, \dots, m-1) \end{aligned}$$

where E_n is an n -th order unitary matrix. Clearly, Ω_i^i is also a matrix of order n .

With Ω_i^i as submatrices, we can form an m -th order partitioned matrix

$$\Omega = (\Omega_i^i)$$

We denote by Ω^* the conjugate matrix of Ω , i.e.

$$\Omega^* = (\Omega_i^i)^* = (\Omega_i^i)^* \quad (2.3)$$

This is because

$$\begin{aligned} \overline{\Omega_i^i} &= \overline{\omega^i} E_n / \sqrt{m} = \exp\left[\frac{-2\pi i j}{m}\right] E_n / \sqrt{m} \\ &= \omega^{-ij} E_n / \sqrt{m} = \Omega_i^i \end{aligned}$$

Below we shall prove a theorem regarding a characteristic of the circulant matrix [2].

Theorem. For a circulant matrix A, we always have

$$\Omega^* A \Omega = C \quad (2.4)$$

where C is a quasidiagonal matrix

$$C = \begin{bmatrix} C_0 & & & \\ & C_1 & & \\ & & C_2 & \\ & & & \ddots \\ & & & & C_{m-1} \end{bmatrix}$$

$C_l (l=0,1,2,\dots, m-1)$ is an n -th order square matrix, and

$$C_l = \sqrt{n} \sum_{k=0}^{m-1} \Omega_l^{*k} A_k$$

where A_k is the partitioned matrix A of order m .

Proof. We write each $n \times n$ submatrix of the m -th order square matrix Ω^* as $C_{lj} (l,j=0,1,2,\dots, m-1)$; then

$$C_{lj} = \sum_{s=0}^{m-1} \sum_{t=0}^{m-1} \overline{\Omega_l^{*s}} A_{st} \Omega_j^{*t} = \sum_{s=0}^{m-1} \sum_{t=0}^{m-1} \Omega_l^{*s} A_{st} \Omega_j^{*t}$$

A is a circulant matrix. From the necessary and sufficient condition for A to be a circulant matrix, we have

$$\begin{cases} A_{s+b} = A_s & (s \geq b) \\ A_{s+b-m} = A_s & (s < b) \end{cases}$$

and $A_{s+b} = A_s \quad (s, b=0,1,\dots, m-1, b=0,1,\dots, m-1)$

so that

$$C_{lj} = \left(\sum_{s=0}^{m-1} \overline{\Omega_l^{*s}} \right) \left(\sum_{t=0}^{m-1} \Omega_j^{*t} A_t \right) \quad (2.5)$$

The first factor in equation (2.5) is

$$\begin{aligned}\sum_{n=0}^{m-1} \Omega_l^{j-n} &= \frac{E_m}{\sqrt{m}} \sum_{n=0}^{m-1} \omega^{(j-n)m} \\ &= \frac{E_m}{\sqrt{m}} (1 + \omega^{j-1} + \omega^{2(j-1)} + \dots + \omega^{(m-1)(j-1)}) \\ &= \begin{cases} \sqrt{m} E_m & \text{when } j-l=0 \\ 0 & \text{when } 0 < j-l \leq m-1 \end{cases}\end{aligned}$$

The last of the equalities in this equation holds because when $0 < j-l \leq m-1$,

$$\begin{aligned}\omega^{j-1} &= \exp \left[\frac{2\pi(j-l)}{m} i \right] \neq 1 \\ \omega^{(j-n)m} &= \exp[2\pi(j-l)i] = 1\end{aligned}$$

and accordingly

$$\frac{E_m}{\sqrt{m}} (1 + \omega^{j-1} + \omega^{2(j-1)} + \dots + \omega^{(m-1)(j-1)}) = \frac{E_m}{\sqrt{m}} \frac{(1 - \omega^{(j-n)m})}{(1 - \omega^{j-1})} = 0$$

Therefore, we immediately obtain from equation (2.5)

$$C_{lj} = \sqrt{m} E_m \delta_{jl} \sum_{n=0}^{m-1} \Omega_l^{j-n} A_n$$

where

$$\delta_{jl} = \begin{cases} 1 & \text{when } j=l \\ 0 & \text{when } j \neq l \end{cases}$$

from which we obtain

$$C_l = \sqrt{m} E_m \sum_{n=0}^{m-1} \Omega_l^{j-n} A_n \quad (l=0, 1, \dots, m-1) \quad (2.6)$$

End of proof.

This theorem shows that when an m -th order circulant matrix A is premultiplied by Ω^* and postmultiplied by Ω , it can be converted to a pseudodiagonal matrix $C = \Omega^* A \Omega$. Each submatrix C_l ($l=0, 1, \dots, m-1$) of C is an n -th order matrix.

We shall use this characteristic of the circulant matrix to derive its inverse.

III. Inversion of the Circulant Matrix

In order to derive the inverse of circulant matrix A, we consider the set of linear algebraic equations with A as coefficient matrix:

$$A\{X\}=\{P\} \quad (3.1)$$

Here A is an m-th order circulant matrix, $\{X\}$ is an unknown vector, and $\{P\}$ is a known vector. We assume, of course, that A can be inverted.

In order to use the theorem just proved, we rewrite the above equation. Let

$$\{X\}=\Omega\{Y\}$$

where $\{Y\}$ is a new, unknown vector, and $\Omega=(\Omega^{ij})$ is the m-th order partitioned matrix described above. Premultiplying both sides of equation (3.1) by Ω^* , we obtain

$$\Omega^* A \Omega \{Y\} = \Omega^* \{P\}$$

From the theorem, the coefficient matrix on the right side of this equation is a pseudodiagonal matrix C, and accordingly

$$C\{Y\}=\Omega^* \{P\}$$

Clearly, C is invertable, and therefore

$$\{Y\}=C^{-1}\Omega^* \{P\}$$

and accordingly

$$\{X\}=\Omega C^{-1}\Omega^* \{P\}$$

This shows that the inverse of circulant matrix A is

$$A^{-1}=\Omega C^{-1}\Omega^* \quad (3.2)$$

For convenience, we write $B=\Omega C^{-1}\Omega^*$. Obviously, B is also an m-th order partitioned matrix, and we write

$$B=(B_{ij}) \quad (i, j=0, 1, \dots, m-1)$$

By the procedure for multiplication of a partitioned matrix, we obtain from equation (3.2)

$$\begin{aligned} B_{ij} &= \sum_{k=0}^{m-1} \sum_{l=0}^{m-1} \Omega_{ik}^* C_{kl}^{-1} \Omega_{lj} = \sum_{k=0}^{m-1} \Omega_{ik}^* C_{kj}^{-1} \Omega_{kk} \\ &= \frac{1}{m} \sum_{k=0}^{m-1} \omega^{jk} \omega^{-ik} C_{kj}^{-1} = \frac{1}{m} \sum_{k=0}^{m-1} \exp \left[\frac{2\pi(i-j)k}{m} \right] C_{kj}^{-1} \end{aligned}$$

from which it follows that if

$$r = \begin{cases} j-l & (j \geq l) \\ j-l+m & (j < l) \end{cases} \quad (l, j = 0, 1, \dots, m-1)$$

then $r=0, 1, \dots, m-1$, and submatrix $B_r = B_{lr}$ is an n -th order square matrix:

$$B_r = \frac{1}{m} \sum_{k=0}^{m-1} \exp \left[\frac{-2\pi r k}{m} i \right] C_k \quad (r=0, 1, \dots, m-1) \quad (3.3)$$

Finally,

$$A^{-1} = \begin{bmatrix} B_0 & B_1 & B_2 & \dots & B_{m-1} \\ B_{m-1} & B_0 & B_1 & \dots & B_{m-2} \\ B_{m-2} & B_{m-1} & B_0 & \dots & B_{m-3} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ B_1 & B_2 & B_3 & \dots & B_0 \end{bmatrix} \quad (3.4)$$

which is the general form for the inverse matrix of circulant matrix A .

The above equation applies for $n \geq 1$.

In particular, when $n = 1$, we obtain a simple and easily applied result. If $n = 1$, then circulant matrix A is an m -th order square matrix

$$A = \begin{bmatrix} a_0 & a_1 & a_2 & \dots & a_{m-1} \\ a_{m-1} & a_0 & a_1 & \dots & a_{m-2} \\ a_{m-2} & a_{m-1} & a_0 & \dots & a_{m-3} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_1 & a_2 & a_3 & \dots & a_0 \end{bmatrix} \quad (3.5)$$

In this case equation (2.6) is simplified to

$$C_l = \sqrt{m} \sum_{k=0}^{m-1} \frac{1}{\sqrt{m}} \exp \left[\frac{2\pi k l}{m} i \right] a_k = \sum_{k=0}^{m-1} \exp \left[\frac{2\pi k l}{m} i \right] a_k \quad (l=0, 1, \dots, m-1) \quad (3.6)$$

and equation (3.3) to

$$B_r = \frac{1}{m} \sum_{i=0}^{m-1} \frac{\exp \left[\frac{-2\pi r u_i}{m} \right]}{\left(\sum_{i=0}^{m-1} \exp \left[\frac{2\pi u h}{m} i \right] a_i \right)} \quad (3.7)$$

Thus we have obtained an explicit expression for the inverse of matrix A, i.e. $A^{-1} = B$. Accordingly, when $n = 1$, if all of the elements $a_0, a_1, a_2, \dots, a_{m-1}$ of circulant matrix A are real, then A^{-1} is generally a complex-valued matrix.

IV. An Important Example

Using the conclusion obtained above, we can immediately find the inverse of the circulant matrix

$$A = \begin{bmatrix} 4 & 1 & 0 & \dots & 0 & 1 \\ 1 & 4 & 1 & \dots & 0 & 0 \\ 0 & 1 & 4 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \dots & 1 & 4 & 1 \\ 1 & 0 & \dots & 0 & 1 & 4 \end{bmatrix}_{m \times m} \quad (4.1)$$

This m -th order circulant matrix is a symmetrical matrix and is frequently encountered [3]. Under the periodicity condition, we obtain this matrix by cubic spline interpolation. As a rule we use equation (4.1) as an algebraic equation for the coefficient matrix when obtaining a solution by the "pursuit" method [1, 3]. But according to the result obtained above, we can immediately write the inverse of equation (4.1), which simplifies the solution process.

Let us find the inverse of matrix (4.1).

Substituting $a_0 = 4, a_1 = 1, a_{m-1} = 1, a_k = 0$ ($k = 2, 3, \dots, m-2$) into equation (3.7), we obtain

$$\begin{aligned}
B_r &= \frac{1}{m} \sum_{i=0}^{m-1} \frac{\exp \left[-\frac{2\pi i r}{m} i \right]}{4 + \exp \left[\frac{2\pi i}{m} i \right] + \exp \left[\frac{2\pi i (m-1)}{m} i \right]} \\
&= \frac{1}{2m} \sum_{i=0}^{m-1} \frac{\cos \frac{2\pi i r}{m} - i \sin \frac{2\pi i r}{m}}{2 + \cos \frac{2\pi i}{m}} \\
&= \frac{1}{2m} \sum_{i=0}^{m-1} \frac{\cos \frac{2\pi i r}{m}}{2 + \cos \frac{2\pi i}{m}} - i \frac{1}{2m} \sum_{i=0}^{m-1} \frac{\sin \frac{2\pi i r}{m}}{2 + \cos \frac{2\pi i}{m}}
\end{aligned}$$

But the sum of all of the terms in the last summation is zero. This is because A is a symmetrical matrix and its inverse must also be symmetrical, so that

$$B_r = B_{m-r}, \quad (r=1, 2, \dots, m-1)$$

But because

$$\begin{aligned}
\cos \frac{2\pi i (m-r)}{m} &= \cos \frac{2\pi i r}{m} \\
\sin \frac{2\pi i (m-r)}{m} &= -\sin \frac{2\pi i r}{m}
\end{aligned}$$

it necessarily follows that

$$\sum_{i=0}^{m-1} \frac{\sin \frac{2\pi i r}{m}}{2 + \cos \frac{2\pi i}{m}} = 0$$

and accordingly

$$B_r = \frac{1}{2m} \sum_{i=0}^{m-1} \frac{\cos \frac{2\pi i r}{m}}{2 + \cos \frac{2\pi i}{m}} \quad (r=0, 1, 2, \dots, m-1) \quad (4.2)$$

Therefore we obtain as the inverse of circulant matrix (4.1)

$$A^{-1} = B = \begin{bmatrix} B_0 & B_1 & B_2 & \dots & B_{m-1} \\ B_{m-1} & B_0 & B_1 & \dots & B_{m-2} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ B_1 & B_2 & B_3 & \dots & B_0 \end{bmatrix} \quad (4.3)$$

in which the elements B_r ($r = 0, 1, 2, \dots, m-1$) are given by equation (4.2).

In conclusion, we add one further point. In order to test the results obtained above, we consider

$$AB = \begin{bmatrix} 4 & 1 & & & & & & 1 \\ & 1 & 4 & 1 & & & & \\ & & 1 & 4 & 1 & & & \\ & & & \ddots & \ddots & \ddots & & \\ & & & & 1 & 4 & 1 & \\ & & & & & 1 & 4 & 1 \\ & & & & & & 1 & 4 \\ 1 & & & & & & & 1 \end{bmatrix} \begin{bmatrix} B_0 & B_1 & B_2 & \dots & B_{m-1} & B_{m-1} \\ B_{m-1} & B_0 & B_1 & \dots & B_{m-1} & B_{m-1} \\ B_{m-1} & B_{m-1} & B_0 & \dots & B_{m-1} & B_{m-1} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ \vdots & \vdots & \vdots & & \ddots & \vdots \\ B_1 & B_1 & B_1 & \dots & B_1 & B_1 \\ B_1 & B_1 & B_1 & \dots & B_{m-1} & B_1 \end{bmatrix}$$

Any element of product matrix AB can be written

$$4a_k + a_{k-1} + a_{k+1} \quad (k=0, 1, \dots, m-1) \quad (4.4)$$

where $k = 0$ represents the diagonal elements and $k = 1, 2, \dots, m-1$ represents all nondiagonal elements. When $k = 0$, $a_{k-1} = a_{m-1}$. Because

$$\begin{aligned} 4a_k + a_{k-1} + a_{k+1} &= \frac{1}{2m} \sum_{n=0}^{m-1} \frac{4 \cos \frac{2\pi kn}{m} + \cos \frac{2\pi(k-1)n}{m} + \cos \frac{2\pi(k+1)n}{m}}{2 + \cos \frac{2\pi n}{m}} \\ &= \frac{1}{2m} \sum_{n=0}^{m-1} \frac{4 \cos \frac{2\pi kn}{m} + 2 \cos \frac{2\pi kn}{m} \cos \frac{2\pi n}{m}}{2 + \cos \frac{2\pi n}{m}} \\ &= \frac{1}{m} \sum_{n=0}^{m-1} \cos \frac{2\pi kn}{m} \\ &= \begin{cases} 1 & \text{当 } k=0 \\ 0 & \text{当 } k=1, 2, \dots, m-1 \end{cases} \end{aligned}$$

therefore

$$AB = E_m$$

Thus matrix B obtained from equation (4.3) is indeed the inverse of matrix A in equation (4.1).

BIBLIOGRAPHY

1. Ahlberg, J.H.; Nilson, E.N.; and Walsh, J.L. "The Theory of Splines and Their Application," Academic Press, 1967.
2. Wu Jike [2976 7139 0668] and Shao Xiumin. "Circulant Matrices and Their Applications to Structural Computations," JISUAN SHUXUE [COMPUTING MATHEMATICS], Vol 1, No 2, 1979.
3. Feng Kang [7458 1660], et al. "Numerical Computation Methods," National Defense Industry Publishing House, 1978.

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APPLIED SCIENCES

THEORY OF INSTABILITY OF THICK ELECTRON BEAM MASERS

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[Article by Yang Xianglin [2799 4382 2651] and Wan Suiren [5502 6659 0086] of Nanjing Institute of Technology: "Theory of Instability of Thick Electron Beam Masers"; paper received January 82, finalized May 82.]

[Text] The characteristics of a thick electron beam and its steady-state distribution function are discussed in this paper. The steady-state distribution function of a practical electron beam was expressed in terms of momentum and position variables or all three momentum variables. The complete form of $V_0 f_0$ and the first order perturbed distribution for both H and E modes of the thick electron beam maser were derived and the decoupling nature of the modes in the thick electron beam maser was proven. The general dispersion equations for H and E modes of a cyclotron maser in any mode and cyclotron harmonics at an arbitrary electron beam thickness, including the term $\partial f_0 / \partial r_0$ were obtained. Furthermore, the properties of a wave guide maser and a cavity maser were discussed. The results will serve as a theoretical basis for calculating thick electron beam masers. They also are more rigorous and precise calculations for a thin layer beam maser.

I. Zeroth Order Steady-state Distribution Function

Considerable results have been obtained by using the relativistic Vlasov-Maxwell equation to study the instability of betatron masers. However, there are still many problems yet to be investigated. Past studies are mostly limited to the interaction between an electron beam of a specific thickness (twice the Larmor radius) and the H mode in a cylindrical or simplified flat plate system^[1-4]. The steady-state distribution of electrons in the phase domain, f_0 , is often described by a double function using two momentum δ variables:

$$f_0 = \frac{1}{2\pi p_\perp} \delta(p_\perp - p_{\perp 0}) \delta(p_\parallel - p_{\parallel 0}) \quad (1)$$

where $p_\perp$ and $p_\parallel$ are the momentum perpendicular and parallel to the uniform steady magnetic field B. From the steady-state Vlasov equation

$$\mathbf{v} \cdot \nabla f_0 - \frac{e}{c} (\mathbf{v} \times \mathbf{B}_0) \cdot \nabla f_0 = 0 \quad (2)$$

we know that f_0 is a function of the motion integral ($p_\perp$ and $p_\parallel$) alone only when electrons are uniformly distributed in the position space. In eq.(2), $\mathbf{v}$ is the velocity vector of the electron, $\mathbf{r}$ is the position variable, $\mathbf{p}$ is the momentum variable, e is the charge of the electron, c is the speed of light in vacuum, ∇f_0 is the gradient of f_0 in the position space, and $\nabla p f_0$ is the gradient of f_0 in the momentum space. Therefore, the distribution of electrons in position space described by eq.(1) is uniform and uncertain. It cannot reflect the position of the electron beam in the wave guide. There is some deviation from reality. The dispersion equation and interaction power thus obtained must contain some error.

In practice, electrons in a cyclotron are not uniformly distributed in position, i.e. $\nabla f_0 \neq 0$. f_0 must be a function of $(\mathbf{r}, \mathbf{p})$. The center of an electron guide cannot possibly be located on a cylindrical surface to form an electron beam with a thickness twice the Larmor radius. Let us assume that this guide center deviates from the ideal cylinder by $(\pm \Delta R_0)$ and the distribution is uniform in this region, as shown in the thick beam model in Figure 1. Jeans theorem points out that any function created by the integral of motion will satisfy the steady-state Vlasov equation. Therefore, the function f_0 can be created by the integral of motion from $p_\perp$, $p_\parallel$ and r_0 (electron guide center radius) or $p_\perp$, $p_\parallel$ and p_0 (sine component of the angular momentum of the electron). The f_0 formed by the integral of motion $(r_0, p_\perp, p_\parallel)$ to describe the model in Figure 1 is

$$f_0(r_0, p_\perp, p_\parallel) = N_z \frac{H[\Delta R_0^2 - (r_0 - R_0)^2]}{4\pi R_0 \Delta R_0} g(p_\perp, p_\parallel) \quad (3)$$

where $g(p_\perp, p_\parallel) = \frac{1}{2\pi p_\perp} \delta(p_\perp - p_{\perp 0}) \delta(p_\parallel - p_{\parallel 0})$, N_z is the linear density of the

electron in the z-direction, $r_0^2 = r^2 + r_L^2 - 2rr_L \sin \hat{\phi}$, $r_L = p_\perp / m_0 \omega_c$, $\omega_c = eB_0 / m_0 c$,

m_0 is the rest mass of electron, $\hat{\phi} = \phi - \theta$, $H(x)$ represents that all the electron guide center r_0 is in the $[R_0 - \Delta R_0, R_0 + \Delta R_0]$ range. When $x \geq 0$ and $x < 0$, $H(x)$ is 1 and 0, respectively. When $\Delta R_0 \rightarrow 0$, it corresponds to an electron ring whose thickness is the diameter of the Larmor center and its guide center is located at R_0 . In this case

$$\lim_{\Delta R_0 \rightarrow 0} \frac{H[\Delta R_0^2 - (r_0 - R_0)^2]}{4R_0 \Delta R_0} = \delta(r_0^2 - R_0^2) \quad (4)$$

The relation among vectors r_0 , r and r_L are shown in Figure 2.

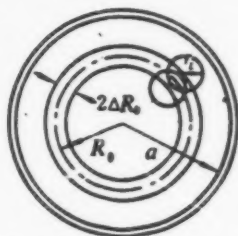


Figure 1. Cross-section of Wave Guide and Electron Beam Model. (B_0 and z axes are pointing out of the paper, a is the wave guide radius, R_0 is the radius of the guide center and r_L is the Larmor radius.)

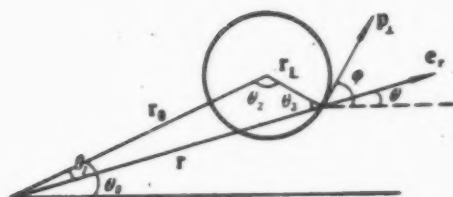


Figure 2. Relation Among r_0 , r and r_L .

The electron beam density function in the wave guide is $n(r) = \int d^3p p(r, p)$, when $\Delta R_0 > r_{Lo}$

$$n(r) = \frac{N_e}{4\pi R_0 \Delta R_0} \begin{cases} \frac{1}{2} - \frac{\phi_{20}}{\pi} & R_0 + \Delta R_0 - r_{Lo} \leq r \leq R_0 + \Delta R_0 + r_{Lo} \\ 1 & R_0 - \Delta R_0 + r_{Lo} \leq r \leq R_0 + \Delta R_0 - r_{Lo} \\ \frac{1}{2} + \frac{\phi_{20}}{\pi} & R_0 - \Delta R_0 - r_{Lo} \leq r \leq R_0 - \Delta R_0 + r_{Lo} \\ 0 & \text{in other regions} \end{cases} \quad (5)$$

When $\Delta R_0 < r_{L0}$

$$n(r) = \frac{N_s}{4\pi R_0 \Delta R_0} \begin{cases} \frac{1}{2} - \frac{\phi_{\pm}}{\pi} & R_0 - \Delta R_0 + r_{L0} \leq r \leq R_0 + \Delta R_0 + r_{L0} \\ \frac{\phi_{\pm} - \phi_{\mp}}{\pi} & R_0 + \Delta R_0 - r_{L0} < r < R_0 - \Delta R_0 + r_{L0} \\ \frac{1}{2} + \frac{\phi_{\mp}}{\pi} & R_0 - \Delta R_0 - r_{L0} \leq r \leq R_0 + \Delta R_0 - r_{L0} \\ 0 & \text{in other regions} \end{cases} \quad (6)$$

When $\Delta R_0 = 0$

$$n(r) = \frac{N_s H(R_0 + r_{L0} - r) \cdot H(r - R_0 + r_{L0})}{\pi^2 [(R_0 + r_{L0})^2 - r^2]^{1/2} [r^2 - (R_0 - r_{L0})^2]^{1/2}} \quad (7)$$

where $r_{L0} = \frac{p_{\perp 0}}{m_0 \omega_c}$, $\phi_{\pm} = \sin^{-1} \frac{r^2 + r_{L0}^2 - (R_0 + \Delta R_0)^2}{2r r_{L0}}$, $\phi_{\mp} = \sin^{-1} \frac{r^2 + r_{L0}^2 - (R_0 - \Delta R_0)^2}{2r r_{L0}}$.

The gradient of the steady-state function in momentum space as defined in eq. (3) is

$$\nabla_p f_0(r_0, p_{\perp}, p_{\parallel}) = e_{\perp} \left[\frac{\partial f_0}{\partial p_{\perp}} + \frac{r_{L0}}{r_0 m_0 \omega_c} \frac{\partial f_0}{\partial r_0} \right] - e_{\parallel} \frac{r}{r_0 m_0 \omega_c} \frac{\partial f_0}{\partial r_0} + e_{\parallel} \frac{\partial f_0}{\partial p_{\parallel}} \quad (8)$$

where $\frac{r_{L0}}{r_0 m_0 \omega_c} \frac{\partial f_0}{\partial r_0}$ and $\frac{r}{r_0 m_0 \omega_c} \frac{\partial f_0}{\partial r_0}$ are two terms due to the

introduction of the integral of motion r_0 to the steady-state distribution. They have not been included in the literature.

II. First Order Perturbed Distribution Function

Let us assume that the electron beam is dilute enough to neglect the space charge field. Based on the model shown in Figure 1, a cavity cyclotron maser is formed by a circular wave guide with a node L. The operating mode in the cavity is H_{mn0} and the standing wave field in the cavity can be decomposed as the superposition of forward and reverse waves.

$$E = E^+ + E^-$$

(9)

The field can be expanded at the guide center as follows:

$$\left. \begin{aligned} E_1^\pm &= \pm \frac{E_0}{2} \sum_{l=-\infty}^{\infty} J'_{-l}(k'_0 r_L) J_{-l}(k'_0 r_0) G_{\pm, l}^\pm(\theta, \phi, z, t) \\ E_0^\pm &= \pm j \frac{E_0}{2} \sum_{l=-\infty}^{\infty} \frac{l}{k'_0 r_L} J_{-l}(k'_0 r_L) J_{-l}(k'_0 r_0) G_{\pm, l}^\pm(\theta, \phi, z, t) \\ B_1^\pm &= \pm j \frac{E_0}{2} \frac{k'_0 c}{\omega} \sum_{l=-\infty}^{\infty} J_{-l}(k'_0 r_L) J_{-l}(k'_0 r_0) G_{\pm, l}^\pm(\theta, \phi, z, t) \\ B_0^\pm &= -j \frac{E_0}{2} \frac{k'_0 c}{\omega} \sum_{l=-\infty}^{\infty} \frac{l}{k'_0 r_L} J_{-l}(k'_0 r_L) J_{-l}(k'_0 r_0) G_{\pm, l}^\pm(\theta, \phi, z, t) \\ B_0^\pm &= \frac{E_0}{2} \frac{k'_0 c}{\omega} \sum_{l=-\infty}^{\infty} J_{-l}(k'_0 r_L) J_{-l}(k'_0 r_0) G_{\pm, l}^\pm(\theta, \phi, z, t) \end{aligned} \right\} \quad (10)$$

where $k_0 = q\pi/L$ and q is a positive integer, $k_n^1 = v_{mn}^1/a$ and v_{mn}^1 is the n th non-zero root of $J_m^1(x) = 0$, $G_{m, l}^\pm = \exp\{j[m\theta_0 + l\theta_2 + k_0 z - \omega t]\}$ and $\theta_0 = \theta + \theta_1$ (see Figure 2). The superscript "+" is used for a wave guide cyclotron maser.

Similarly, the expansion of the field in the E mode near the wave guide center can be obtained.

The first order perturbed distribution function is:

$$f_0(r, p, t) = e \int_{t_1}^t dt' \left[E' + \frac{1}{c} v' \times B' \right] \cdot \nabla_r f_0(r', p') \quad (11)$$

where all terms with "'" are functions of t' . For a cavity maser, $t_1 = t - z/v_0$. For a wave guide maser, $t_1 \rightarrow -\infty$.

Among all the terms in the expansion near the center of the wave guide, only $G_{m, 1}^\pm(\theta, \phi, z, t)$ is a function of t . From the unperturbed equation of motion we get

$$G_{m, l}(\theta', \phi', z', t') = G_{m, l}(\theta, \phi, z, t) \exp[j(\omega - k_0 v_0 - l\Omega)\tau], \quad \Omega = \omega_e/\gamma, \quad \gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}, \quad \tau = t - t'.$$

By substituting eq. (8) and (10) into (11), we get

$$f_{1H}^{\pm} = \pm j \frac{eE_0}{2} \sum_{i=-\infty}^{\infty} \left\{ \left[\left(1 \mp \frac{k_{\parallel} v_{\parallel}}{\omega} \right) \frac{\partial f_0}{\partial p_{\perp}} \pm \frac{k_{\parallel} v_{\parallel}}{\omega} \frac{\partial f_0}{\partial p_{\parallel}} \right] J'_{-i}(k'_{\perp} r_L) J_{-i}(k'_{\perp} r_0) \right. \\ \left. - \frac{\partial f_0 / \partial r_0}{m_0 \omega_c} (J_{-i}(k'_{\perp} r_L) J'_{-i}(k'_{\perp} r_0) e^{\pm} + \frac{m-1}{r_0} r_L J'_{-i}(k'_{\perp} r_L) J_{-i}(k'_{\perp} r_0) \Omega) \right\} \frac{\chi^{\pm}}{e^{\pm}} G_{m,i} \quad (12)$$

where $e^{\pm} = \omega \mp k_{\parallel} v_{\parallel} - l \Omega$, $\text{Im}(e^{\pm}) > 0$, $\chi^{\pm} = 1 - \exp(j e^{\pm} z / v_{\parallel})$, and "+" represents the perturbation caused by the forward and reverse wave field, respectively. In a wave guide maser, only the "+" terms are considered. Moreover, $\lim_{\chi \rightarrow \infty} \chi^{\pm} = 1$. The subscript "H" represents the H mode perturbed distribution function.

Similarly, we can get the E mode perturbed distribution function

$$f_{1E} = \frac{eE_0 \omega}{k_{\perp} c} \sum_{i=-\infty}^{\infty} \left\{ \left[\frac{l}{k_{\perp} r_L} \left(\frac{k_{\parallel} c}{\omega} - \frac{v_{\parallel}}{c} \right) \frac{\partial f_0}{\partial p_{\perp}} + \left(\frac{l \Omega}{k_{\perp} c} - \frac{k_{\perp} c}{\omega} \right) \frac{\partial f_0}{\partial p_{\parallel}} \right] \right. \\ \left. + \frac{\partial f_0 / \partial r_0}{m_0 \omega_c} \frac{m-1}{k_{\perp} r_0} \left(\frac{v_{\parallel}}{c} - \frac{k_{\parallel} c}{\omega} \right) \right\} \frac{J_{-i}(k_{\perp} r_L) J_{-i}(k_{\perp} r_0)}{\omega - k_{\parallel} v_{\parallel} - l \Omega} G_{m,i} \quad (13)$$

where $K_{\mu} = v_{\mu\parallel} / a$ and $v_{\mu\parallel}$ is the μ th non-zero root of $J_m(x) = 0$

III. Decoupling Nature of Modes

The dispersion equation, mode coupling and instability can be studied by using the perturbed distribution function.

Let us assume that various H and E modes exist in the wave guide. The total B_z field of the H modes is $B_z = \sum_i B_i^H$ where i is the H mode number. The total E_z field of the E modes is $E_z = \sum_s E_s^E$ where s is the E mode sequence. Using Maxwell equation, we get

$$\sum_i \left(\frac{\omega_i^2}{c^2} - k_{\parallel i}^2 - k_{\perp i}^2 \right) B_i^H = -\frac{4\pi}{c} \sum_i (\nabla \times J_i)_z - \frac{4\pi}{c} \sum_i (\nabla \times J_s)_z \quad (14)$$

$$\sum_s \left(\frac{\omega_s^2}{c^2} - k_{\parallel s}^2 - k_{\perp s}^2 \right) E_s = 4\pi j \sum_i k_{\parallel i} \left(\rho_i - \frac{\omega_i}{k_{\parallel i} c^2} J_{i,z} \right) + 4\pi j \sum_i k_{\parallel i} \left(\rho_s - \frac{\omega_s}{k_{\parallel s} c^2} J_{s,z} \right) \quad (15)$$

where k'_{ci} and k'_{cs} are the cutoff wave number of the H_i and E_s modes, respectively. J_i , J_s and ρ_i , ρ_s are the first order and zeroth order moment of f_{1H}^i and f_{1E}^i with respect to velocity v , respectively. f_{1H}^i and f_{1E}^i are the perturbed distribution functions of parallel H_i and E_s modes, respectively.

Let us multiply both sides of eq. (14) by B_Z^{m*} and both sides of eq. (15) by E_Z^{n*} . Then, we get the following by integrating in the wave guide:

$$\begin{aligned} & \sum_i \left(\frac{\omega_i^2}{c^2} - k_{zi}^2 - k'_{zi}{}^2 \right) \lim_{Z \rightarrow \infty} \int_0^Z dz \int_0^{2\pi} d\theta \int_0^a r dr B_i^{m*} \cdot B_i^{m*} \\ &= -\frac{4\pi}{c} \sum_i \lim_{Z \rightarrow \infty} \int_0^Z dz \int_0^{2\pi} d\theta \int_0^a r dr B_i^{m*} \cdot (\nabla \times J_i)_z - \frac{4\pi}{c} \lim_{Z \rightarrow \infty} \int_0^Z dz \\ & \quad \int_0^{2\pi} d\theta \int_0^a r dr B_i^{m*} (\nabla \times J_i)_z \end{aligned} \quad (16)$$

$$\begin{aligned} & \sum_i \left(\frac{\omega_i^2}{c^2} - k_{zi}^2 - k'_{zi}{}^2 \right) \lim_{Z \rightarrow \infty} \int_0^Z dz \int_0^{2\pi} d\theta \int_0^a r dr E_i^{n*} \cdot E_i^{n*} \\ &= 4\pi j \sum_i \lim_{Z \rightarrow \infty} \int_0^Z dz \int_0^{2\pi} d\theta \int_0^a r dr k_{zi} \left(\rho_i - \frac{\omega_i}{k_{zi} c^2} J_{iz} \right) \cdot E_i^{n*} \\ &+ 4\pi j \sum_i \lim_{Z \rightarrow \infty} \int_0^Z dz \int_0^{2\pi} d\theta \int_0^a r dr k_{si} \left(\rho_s - \frac{\omega_s}{k_{si} c^2} J_{sz} \right) \cdot E_i^{n*} \end{aligned} \quad (17)$$

For a sufficiently dilute electron beam, the function to be integrated on the left of eq. (16) is the product of orthogonal modes. All $i \neq m$ terms are zero. Then, eq. (16) becomes:

$$\begin{aligned} & \left(\frac{\omega_m^2}{c^2} - k_{zm}^2 - k'_{zm}{}^2 \right) \lim_{Z \rightarrow \infty} \int_0^Z dz \int_0^{2\pi} d\theta \int_0^a r dr B_m^{m*} \cdot B_m^{m*} \\ &= \left(\frac{\omega_m^2}{c^2} - k_{zm}^2 - k'_{zm}{}^2 \right) \lim_{Z \rightarrow \infty} Z \cdot S N_{mz} \frac{k'_{zm}{}^2 c^2}{\omega_m^2} \end{aligned} \quad (18)$$

where $S = \pi a^2$, $N_{mz} = \left(1 - \frac{m^2}{k_{zm}^2 a^2} \right) J_m^2(k'_{zm} a)$, $k'_{zm} = k'_{zm}$.

By dividing both sides of eq. (16) by $\lim_{Z \rightarrow \infty} Z \cdot S N_{mz} \frac{k'_{zm}{}^2 c^2}{\omega_m^2}$, we get

$$\begin{aligned}
\frac{\omega_m^2}{c^2} - k_{||m}^2 - k_{\perp m}^2 &= \frac{e^2 \pi \omega_m}{m_e k_{\perp m}^2 c^2 S N_{em}} \sum_i \sum_{l=-\infty}^{\infty} \sum_{l'=-\infty}^{\infty} \int_0^{\infty} d\rho_{\perp} \int_{-\infty}^{\infty} d\rho_{\parallel} \int_0^{\infty} r_0 dr_0 \\
&\cdot k_{\perp i} E_m^* E_0^i \frac{\rho_{\perp}^2}{r} J_{l-l'}^*(k_{\perp i} r_L) J_{l-l'}(k_{\perp m} r_0) \left\{ \left[\left(1 - \frac{k_{||i} v_{||}}{\omega_i} \right) \frac{\partial f_0}{\partial \rho_{\perp}} \right. \right. \\
&+ \left. \frac{k_{||i} v_{||}}{\omega_i} \frac{\partial f_0}{\partial \rho_{\parallel}} \right] J_{l-l'}^*(k_{\perp i} r_L) J_{l-l'}(k_{\perp m} r_0) - \frac{\partial f_0 / \partial r_0}{m_e \omega_e} \left[J_{l-l'}(k_{\perp i} r_L) \right. \\
&\cdot J_{l-l'}(k_{\perp m} r_0) \epsilon^+ + \left. \frac{i-l}{r_0} r_L J_{l-l'}^*(k_{\perp i} r_L) J_{l-l'}(k_{\perp m} r_0) \Omega \right] \left. \right\} \frac{1}{\epsilon^+} \\
&\cdot \lim_{Z \rightarrow \infty} \frac{1}{Z} \int_0^Z dz \int_0^{2\pi} d\theta_0 \int_0^{2\pi} d\theta_1 \cdot \exp \{ j[(i-m)\theta_0 + (l-l')\theta_1 \\
&+ (k_{||i} - k_{||m})z - (\omega_i - \omega_m)t] \} - j \frac{2\pi e^2 \omega_m}{m_e k_{\perp m}^2 c^2 S N_{em}} \sum_i \sum_{l=-\infty}^{\infty} \\
&\cdot \sum_{l'=-\infty}^{\infty} \int_0^{\infty} d\rho_{\perp} \int_{-\infty}^{\infty} d\rho_{\parallel} \int_0^{\infty} r_0 dr_0 \cdot \omega_i E_m^* \cdot E_0^i \frac{\rho_{\perp}^2}{r} J_{l-l'}^*(k_{\perp i} r_L) \\
&\cdot J_{l-l'}(k_{\perp m} r_0) \left\{ \left[\frac{l}{k_{\perp i} r_L} \left(\frac{k_{||i} c}{\omega_i} - \frac{v_{||}}{c} \right) \frac{\partial f_0}{\partial \rho_{\perp}} + \left(\frac{l \Omega}{k_{\perp i} c} - \frac{k_{\perp i} c}{\omega_i} \right) \right. \right. \\
&\cdot \left. \frac{\partial f_0}{\partial \rho_{\parallel}} \right] + \frac{\partial f_0 / \partial r_0}{m_e \omega_e} \frac{s-l}{k_{\perp i} r_0} \left(\frac{v_{||}}{c} - \frac{k_{||i} c}{\omega_i} \right) \left. \right\} \frac{J_{l-l'}(k_{\perp i} r_L) J_{l-l'}(k_{\perp m} r_0)}{\omega_i - k_{||i} v_{||} - l \Omega} \\
&\cdot \lim_{Z \rightarrow \infty} \frac{1}{Z} \int_0^Z dz \int_0^{2\pi} d\theta_0 \int_0^{2\pi} d\theta_1 \cdot \exp \{ j[(s-m)\theta_0 + (l-l')\theta_1 \\
&+ (k_{||s} - k_{||m})z - (\omega_s - \omega_m)t] \}
\end{aligned} \tag{19}$$

where E_m^m , E_0^i and E_s^s are the amplitudes of the H_m , H_i and H_s modes. The integration under the summation sign in eq. (19) is not zero only when $i=m$, $l=l'$ and $k_{||i}=k_{||m}$. This suggests that the H_m and H_i modes ($i \neq m$) are not coupled through the electron beam. Similarly, the integral under $\sum_s$ is not zero only when $s=m$, $l=l'$ and $k_{||s}=k_{||m}$. However, because $k_{||s}$ is the propagation constant for the E mode and $k_{||m}$ is that for H mode, they will never be equal unless it is a degenerate mode. If it is degenerate, then $s \neq m$. Therefore, this integral is always zero, which means that the H_m mode will not couple with the E_s mode through the electron beam. Similar conclusions can be obtained for the integral in eq. (17) based on the principle of symmetry.

We can see that the E and H modes do not couple in a dilute electron cyclotron maser. They are completely decoupled, even in a degenerated mode. The energy exchange between a mode and the electron beam is also independent in a cavity maser. This decoupling nature is not related to the zeroth order distribution function, i.e. unrelated to the equilibrium state of the electrons. This is in agreement with the anticipated result when we use linear approximation and neglect the space charge field. Hence, it can be used to study the dispersion equation, instability and power function for each individual mode.

IV. Dispersion Equation

The dispersion equation for the H mode of a circular wave guide-thick electron beam model is:

$$\frac{\omega^2}{c^2} - k_z^2 - k_{\perp}^2 = \frac{4\pi\nu}{\gamma_0 S N_{\perp}} \left\{ \varepsilon_{H1}(a_0, a_L, \Delta a_0) + \frac{\Omega_0 \varepsilon_{H2}(a_0, a_L, \Delta a_0)}{\omega - k_z v_{H0} - l \Omega_0} \right. \\ \left. + \left[\frac{(\omega - k_z v_{H0}) Q_{m-1}^H(a_0, a_L)}{\omega - k_z v_{H0} - l \Omega_0} - \frac{\beta_{L0}^2 (\omega^2 - k_z^2 c^2) H_{m-1}^H(a_0, a_L)}{(\omega - k_z v_{H0} - l \Omega_0)^2} \right] \cdot \zeta(a_0, \Delta a_0) \right\} \quad (20)$$

where the subscripts i and m are dropped in ω , k_z and $k_{\perp}^2$.

$$\nu = e^2 N_0 / m_0 c^2, \quad a_0 = k_z' R_0$$

$$a_L = k_z' r_{L0}, \quad \Delta a_0 = k_z' \Delta R_0, \quad \gamma_0 = \left(1 + \frac{p_{L0}^2 + p_{\perp 0}^2}{m_0^2 c^2} \right)^{1/2}, \quad \Omega_0 = \frac{\omega_c}{\gamma_0}, \quad \beta_{L0} = \frac{p_{L0}}{m_0 \gamma_0 c}, \\ H_{m-1}^H(a_0, a_L) = [J_1'(a_L) J_{m-1}(a_0)]^2 \quad (21)$$

$$Q_{m-1}^H(a_0, a_L) = a_L \left(\frac{l^2}{a_L^2} - 1 \right) [J_1^2(a_L)]' J_{m-1}^2(a_0) \quad (22)$$

$$\zeta(a_0, \Delta a_0) = \frac{J_{m-2}^2(a_0)}{4a_0 \Delta a_0} \{ a_{02}^2 [J_{m-1}^2(a_m) - J_{m-1-1}(a_m) J_{m-1+1}(a_m)] \\ - a_m^2 [J_{m-1}^2(a_m) - J_{m-1-1}(a_m) J_{m-1+1}(a_m)] \} \quad (23)$$

$$\varepsilon_{H1}(a_0, a_L, \Delta a_0) = \sum_{l=-\infty}^{\infty} \frac{a_L}{4a_0 \Delta a_0} [J_1^2(a_L)]' \{ a_m [J_{m-1}^2(a_m)]' - a_m [J_{m-1}^2(a_m)]' \} \\ \varepsilon_{H2}(a_0, a_L, \Delta a_0) = \frac{a_L^2}{\Delta a_0} \frac{m-1}{a_0} J_1^2(a_L) [J_{m-1}^2(a_m) - J_{m-1}^2(a_m)] \quad (24)$$

$$a_m = a_0 - \Delta a_0, \quad a_{\bar{m}} = a_0 + \Delta a_0$$

The E mode dispersion equation is

$$\frac{\omega^2}{c^2} - k_z^2 - k_{\perp}^2 = \frac{4\pi\nu}{\gamma_0 S K_{\perp}} \left\{ \left[\frac{Q_{m-1}^E(b_0, b_L) \zeta(b_0, \Delta b_0) + \varepsilon_E(b_0, b_L, \Delta b_0)}{\Omega_0 (\omega - k_z v_{H0} - l \Omega_0)} \right. \right. \\ \left. - \frac{H_{m-1}^E(b_0, b_L) \cdot \zeta(b_0, \Delta b_0)}{(\omega - k_z v_{H0} - l \Omega_0)^2} \right] \left(\frac{\omega v_{H0}}{c} - k_z c \right)^2 \\ \left. - \left(\frac{\omega^2}{c^2} - k_z^2 - k_{\perp}^2 \right) \frac{l \Omega_0}{k_{\perp}^2} \cdot H_{m-1}^E(b_0, b_L) \zeta(b_0, \Delta b_0) \right\} \quad (25)$$

where

$$b_0 = k_p R_0, \quad b_L = k_p r_{L0}, \quad \Delta b_0 = k_p \Delta R_0, \quad K_{m,p} = J_m'^2(k_p a),$$

$$H_{m,-1}^{\pm}(b_0, b_L) = J_m^{\pm}(b_L) J_{m-1}^{\pm}(b_0) \quad (26)$$

$$Q_{m,-1}^{\pm}(b_0, b_L) = \frac{1}{b_L} [J_m^{\pm}(b_L)]' J_{m-1}^{\pm}(b_0) \quad (27)$$

$$\varepsilon_z(b_0, b_L, \Delta b_0) = \frac{m-1}{b_0} J_m^2(b_L) \frac{1}{2\Delta b_0} [J_{m-1}^2(b_0) - J_{m-1}^2(b_0)] \quad (28)$$

In dispersion equations (20) and (25), τ is the geometric correction factor for a thick electron beam relative to a thick electron beam with a thickness of twice the radius of the Larmor radius. $\tau \leq 1$ and $\lim_{m \rightarrow 0} \tau = 1$. ε_H and ε_E are added due to the introduction of the motion integral r_0 and the $\partial f_0 / \partial r_0$ term.

When $\Delta R_0 \gg 0$, the dispersion equation for a thick electron beam with a thickness of twice the Larmor radius can be obtained from eq. (20) and (25). In this case, we have

$$\left. \begin{aligned} \varepsilon_{H1}(a_0, a_L, 0) &= - \sum_{l=-\infty}^{\infty} \frac{a_L}{2} [J_l^2(a_L)]' \left\{ \frac{1}{a_0} [J_{m-1}^2(a_0)]' + [J_{m-1}^2(a_0)]'' \right\} \\ \varepsilon_{H2}(a_0, a_L, 0) &= 2a_L^2 \frac{m-1}{a_0} J_l'^2(a_L) [J_{m-1}^2(a_0)]' \end{aligned} \right\} \quad (29)$$

$$\varepsilon_z(b_0, b_L, 0) = \frac{m-1}{b_0} J_m^2(b_L) [J_{m-1}^2(b_0)]' \quad (30)$$

When $\Delta R_0 = R_0$, $a_{01} = b_{01} = 0$. In this situation, the inner edge of the thick electron wave guide center circle shrinks back to $r=0$. The electron beam becomes solid. From eq. (20) and (25), we can obtain a solid dispersion equation. For the H mode, we have:

$$\frac{\omega^2}{c^2} - k_{||}^2 - k_{\perp}^2 = \frac{4\pi\nu}{\gamma_0 S N_{\text{max}}} \left\{ \varepsilon_{H1}^s(a_0, a_L) + \frac{Q_0 \varepsilon_{H2}^s(a_0, a_L) + (\omega - k_{||} v_{10}) Q_{m,-1}^{Hs}(a_0, a_L)}{\omega - k_{||} v_{10} - l \Omega_0} - \frac{\beta_{\perp 0}^2 (\omega^2 - k_{||}^2 c^2) H_{m,-1}^{Hs}(a_0, a_L)}{(\omega - k_{||} v_{10} - l \Omega_0)^2} \right\} \quad (31)$$

$$\left. \begin{aligned} \varepsilon_{H1}^s(a_0, a_L) &= - \sum_{l=-\infty}^{\infty} \frac{a_L}{a_0} [J_l^2(a_L)]' [J_{m-1}^2(a_0)]' \\ \varepsilon_{H2}^s(a_0, a_L) &= \frac{4a_L^2}{a_0^2} (m-1) J_l'^2(a_L) J_{m-1}^2(a_0) \end{aligned} \right\} \quad (32)$$

$$H_{m,-1}^{Hs}(a_0, a_L) = J_l'^2(a_L) [J_{m-1}^2(a_0) - J_{m-1-1}(a_0) J_{m-1+1}(a_0)] \quad (33)$$

$$Q_{m,-1}^{Hs}(a_0, a_L) = a_L \left(\frac{l^2}{a_L^2} - 1 \right) [J_l^2(a_L)]' [J_{m-1}^2(a_0) - J_{m-1-1}(a_0) J_{m-1+1}(a_0)] \quad (34)$$

where a_0 is the product of the inner radius of the electron guide center circle and k_n' .

With respect to the E mode

$$\frac{\omega^2}{c^2} - k_{||}^2 - k_{\perp}^2 = \frac{4\pi\nu}{\gamma_0 S K_{m\mu}} \left\{ \left[\frac{\theta_{m,l}^{E,S}(b_0, b_L) + \varepsilon_E^S(b_0, b_L)}{\Omega_0(\omega - k_{||}v_{||0} - l\Omega_0)} - \frac{H_{m,l}^{E,S}(b_0, b_L)}{(\omega - k_{||}v_{||0} - l\Omega_0)^2} \right] \right. \\ \left. + \left(\frac{\omega v_{||0}}{c} - k_{||} \right)^2 - \frac{\left(\frac{\omega^2}{c^2} - k_{||}^2 - k_{\perp}^2 \right) \frac{l\Omega_0}{k_{\perp}^2} H_{m,l}^{E,S}(b_0, b_L)}{\omega - k_{||}v_{||0} - l\Omega_0} \right\} \quad (35)$$

$$H_{m,l}^{E,S}(b_0, b_L) = J_l^2(b_L) [J_{m-l}^2(b_0) - J_{m-l-1}(b_0) J_{m-l+1}(b_0)] \quad (36)$$

$$Q_{m,l}^{E,S}(b_0, b_L) = \frac{l}{b_L} [J_l^2(b_L)]' [J_{m-l}^2(b_0) - J_{m-l-1}(b_0) J_{m-l+1}(b_0)] \quad (37)$$

$$\varepsilon_E^S(b_0, b_L) = \frac{2(m-l)}{b_0^2} J_l^2(b_L) J_{m-l}^2(b_0) \quad (38)$$

where b_0 is the product of the outer radius of the electron guide center circle and $k_{\perp}$.

V. Calculation of Characteristics of Thick Electron Beam Masers

1. Deviation from Linearity and Rate of Increase of Wave Guide Masers.

Let $\omega = \omega_0 + \delta\omega$, and $\omega_0 = c\sqrt{k_{||}^2 + k_{\perp}^2} = k_{||}v_{||0} + l\Omega_0$, then eq. (20) becomes

$$\delta^3\omega - \frac{2\pi\nu c^2}{\gamma_0 S N_{mn}\omega_0} \{ \varepsilon_{m,l} \delta^2\omega + \Omega_0(\varepsilon_{m,l} + lQ_{m,l}^H)\delta\omega - \beta_{\perp 0}^2 c^2 k_{\perp}^2 H_{m,l}^H \} \zeta = 0 \quad (39)$$

We can then calculate the linearity deviation, $\delta\omega_r$, and rate of increase, $\delta\omega_i$, are

$$\delta\omega_r \approx \delta\omega_0^0 [\zeta(a_0, \Delta a_0)]^{1/3}, \quad \delta\omega_0^0 = \frac{1}{2} \left[\frac{2\pi\nu k_{\perp}^2 c^2 v_{||0}^2 H_{m,l}^H}{\gamma_0 S N_{mn}\omega_0} \right]^{1/3} \quad (40)$$

$$\delta\omega_i = \sqrt{3} \delta\omega_r \quad (41)$$

where $\delta\omega_0^0$ is the frequency deviation of an ideal single layer beam, $[\zeta(a_0, \Delta a_0)]^{1/3}$ is a correction for the deviation of the center of the guide.

2. Power of Interaction in Cavity Masers.

The power of interaction between the electron beam and the field is

$$P_s = \frac{1}{2} \int_v E \cdot J^* dV = P_{sr} + jP_{si} \quad (42)$$

$$P_{sr} = \frac{\nu E_0^2 c^2}{4\omega\gamma_0} \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) \tau_0 \sin^2 \frac{\Delta}{2} \left[k_{m,i}^H \tau_0 \beta_{i0}^2 \left\{ (\omega^2 - k_{ii}^2 c^2) \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) \cdot \left[\frac{1}{2} \cos \frac{\Delta}{2} - \left(\frac{1}{\Delta} + \frac{1}{\Delta'} \right) \right] L - k_{ii} C^2 \left[\cos \frac{\Delta}{2} - \left(\frac{1}{\Delta} + \frac{1}{\Delta'} \right) \right] \right\} + q_{m,i}^H L \cdot \left(\frac{\omega - k_{ii} v_{ii0}}{\Delta} - \frac{\omega + k_{ii} v_{ii0}}{\Delta'} \right) - \varepsilon_H \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) L \Omega_0 \right] \quad (43)$$

$$P_{si} = \frac{\nu E_0^2 c^2}{8\omega\gamma_0} \tau_0 \left[k_{m,i}^H \tau_0 \beta_{i0}^2 \left\{ (\omega^2 - k_{ii}^2 c^2) L \left[\cos \Delta - 2 \left(\frac{1}{\Delta} + \frac{1}{\Delta'} \right) \sin \Delta \right] \cdot \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right)^2 + \left(\frac{1}{\Delta^2} + \frac{1}{\Delta'^2} \right) \right\} + 2k_{ii} c^2 \left[\left(\frac{1}{\Delta} + \frac{1}{\Delta'} \right) \sin \Delta - \cos \Delta \right] \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) \right\} - q_{m,i}^H L \left\{ \frac{\omega - k_{ii} v_{ii0}}{\Delta} \left[1 - \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) \sin \Delta \right] + \frac{\omega + k_{ii} v_{ii0}}{\Delta'} \left[1 + \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) \sin \Delta \right] \right\} + \varepsilon_H L \Omega_0 \left[\left(\frac{1}{\Delta} + \frac{1}{\Delta'} \right) - \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right)^2 \sin \Delta \right] \right\} \quad (44)$$

where $k_{m,i}^H = H_{m,i}^H(a_0, a_L) \zeta(a_0, \Delta a_0)$, $q_{m,i}^H = Q_{m,i}^H(a_0, a_L) \cdot \zeta(a_0, \Delta a_0) + \varepsilon_{H1}(a_0, a_L, \Delta a_0)$, $\varepsilon_H = l \varepsilon_{H1}(a_0, a_L, \Delta a_0) - \varepsilon_{H2}(a_0, a_L, \Delta a_0)$, $\tau_0 = L/v_{ii0}$, $\Delta = (\omega - k_{ii} v_{ii0} - l \Omega_0) \tau_0$, $\Delta' = (\omega + k_{ii} v_{ii0} - l \Omega_0) \tau_0$.

ε_{H1} is the 1 term in ε_{H1} .

3. Resonance Current and Frequency Offset.

When a cavity maser works stably

$$-P_{sr} = \omega W / Q_L \quad (45)$$

where Q is the carrier quality factor in the cavity. The energy stored in the cavity is

$$W = \frac{E_0^2}{16} L a^2 \left(1 - \frac{m^2}{k_{ii}^2 a^2} \right) J_m^2(k_{ii}' a).$$

The electron beam power P_b and the threshold resonance power P_b^{th} are

$$P_b = m_0 (\gamma_0 - 1) c^2 N_{ii} v_{ii0} \quad (46)$$

$$P_b^{\text{th}} = - \frac{\bar{\omega}^2 \beta_{ii0}^2 \gamma_0 (\gamma_0 - 1)}{Q_L L a} \left(1 - \frac{m^2}{k_{ii}^2} \right) J_m^2(k_{ii}') \frac{m_0^2 c^3}{4 \times 10^{10} e^2} \quad (47)$$

where

$$\alpha = \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) \sin^2 \frac{\Delta}{2} \left[h_{m,1}^H \bar{\tau}_0 \beta_{10}^2 \left\{ (\bar{\omega}^2 - \bar{k}^2) \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) \left[\frac{1}{2} \cos \frac{\Delta}{2} - \left(\frac{1}{\Delta} + \frac{1}{\Delta'} \right) \right] - \bar{k}_H \bar{L}^{-1} \left[\cos \frac{\Delta}{2} - \left(\frac{1}{\Delta} + \frac{1}{\Delta'} \right) \right] \right\} + q_{m,1}^H \left(\frac{\bar{\omega} - \bar{k}_H \beta_{10}}{\Delta} - \frac{\bar{\omega} + \bar{k}_H \beta_{10}}{\Delta'} \right) - \varepsilon_H \left(\frac{1}{\Delta} - \frac{1}{\Delta'} \right) \bar{Q}_0 \right]$$

$\bar{L} = L/a$, $\bar{\tau}_0 = \tau_0 c/a$, $\bar{\omega} = \omega a/c$, $\bar{Q}_0 = Q_0 a/c$. The power unit is kW. M_0 , e and c are in Gauss units.

The resonance current I_{st} and frequency offset $\Delta\omega/\omega$ are

$$I_{st} = -\frac{5\bar{\omega}^2 \beta_{10} \gamma_0}{2Q_L \bar{L} \alpha} \left(1 - \frac{m^2}{\bar{k}^2} \right) J_m^2(\bar{k}') \frac{m_0 c^2}{e} \quad (48)$$

$$\frac{\Delta\omega}{\omega_0} = -\frac{P_{st}}{2\omega W}, \quad \Delta\omega = \omega - \omega_0. \quad (49)$$

REFERENCES

1. M. Friedman et al., Phys. Rev. Lett., Vol. 31, pp. 752-755, 1973.
2. E. Ott et al., IEEE Trans., Vol. PS-3, pp. 1-5, 1975.
3. P. Sprangle et al., IEEE Trans., Vol. MTT-25, pp. 528-544, 1977.
4. Liu Shenggang, Scientia Sinica, No. 5, p. 905, 1979.
5. K.R. Chu et al., Phys. Fluids, Vol. 21, No. 3, pp. 461-466, 1978.
6. K.R. Chu, Phys. Fluids, Vol. 21, No. 12, pp. 2354-2364, 1978.

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CSO: 4008/260

APPLIED SCIENCES

PHASE DISTRIBUTION OF PHASED ARRAY LENS ANTENNA

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11 No 3, May 83
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[Article by Xiang Zhengping [4161 2973 1627] of Nanjing Institute of Electronic Technology]: "Study of Phase Distribution for Phased Array Lens Antenna";
paper received April 82, finalized July 82.]

[Text] Abstract: A passive lens based on the principle of prismatic refraction was introduced to amplify the scan angle of a phased array antenna. The lens might consist of an array of curved surface of revolution or a dielectric material. Formulas to calculate array lens phase distribution, configuration curve of the dielectric lens and aperture phase distribution of a planar phased antenna. When used in combination with a planar phased antenna, this lens enables a planar phased antenna beam to achieve hemispherical coverage.

I. Introduction

Since the 1960's, planar phased antennas have been rapidly developed and widely used. However, its scan angle has to be less than 70° . Otherwise, its linearity will decrease noticeably. Therefore, if hemispherical scanning is required, it is necessary to use many planar arrays. In order to expand the scan angle of a planar array, a combination of phased array and lens can satisfy this requirement[1].

The basic principle of this lens is similar to prismatic refraction in optics. As shown in Figure 1, the angle between the reflected light and the z-axis is increased relative to the angle θ when the light is reflected by the prism. $K = \Psi/\theta$ is the magnifying factor and $\Psi > \theta, K > 1$. This effectively magnifies the incident angle of the light beam. The phased array-lens combination is composed of a feed planar phased array and an array of passive lenses[1]. As shown in Figure 2, l is a passive lens, e is a transmitting and receiving antenna element with a fixed phase distribution and F is a feed array which is an ordinary planar phased array. In this work, the passive lens may be an array of any surface of revolution. As a special case, it may be spherical. The phase delay is fixed in the lens array in order to lower cost.

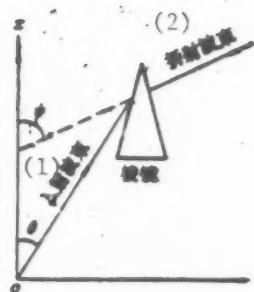


Figure 1. Principle of Prismatic Refraction

Key:

- 1. incident beam
- 2. refracted beam

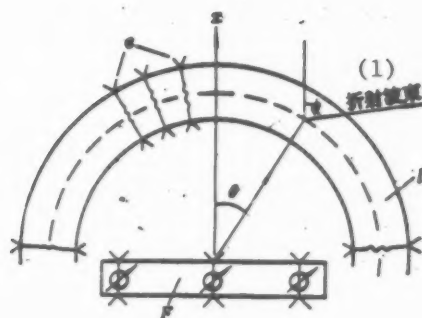


Figure 2. Schematic Diagram of Array Lens Antenna

Key:

- 1. refracted beam

II. Formulas for Fixed Phase Delay

When an electromagnetic wave propagates in a medium, the direction of propagation is curved toward the lagging phase. Therefore, it is necessary to provide a phase gradient by the lens in order to increase the scan angle of the planar array. The wave transmitted from the center of the feed planar array obtains an additional phase after passing through a point on the lens to avoid a change of direction of propagation. To this end, it is necessary to add a fixed phase delay on the lens element. In the following, the formulas for fixed phase delay are derived. Let us assume that the lens array is a curved surface of revolution formed by a curve $r(\theta)$ around the z -axis. Antenna elements are evenly distributed on this curved surface. We require that the lens should have a magnifying effect on the scan angle in the θ direction. The scan shall remain symmetric in the azimuth direction.

As shown in Figure 3, the wave front QS of the reflected beam is an equi-phase plane. In order to make the field at S equal to that at Q , the phase difference caused by MS should be equal to the phase increment $d\phi$ at point Q relative to M , i.e.

$$\frac{2\pi}{\lambda} dr + d\phi = \frac{2\pi}{\lambda} \sin \beta \cdot dS \quad (1)$$

In addition

$$\begin{aligned} \beta &= \psi - \theta + i \quad \text{and} \quad \psi = K\theta, \text{ therefore} \\ \beta &= (K-1)\theta + i \end{aligned} \quad (2)$$

where i is the angle between the radial vector and the normal of the curved surface and β is the angle between the refracted beam and the normal direction. Furthermore, there are:

$$\operatorname{tg} i = dr/r d\theta \quad (3)$$

$$dS = \sqrt{r^2 + \left(\frac{dr}{d\theta}\right)^2} \cdot d\theta = \frac{r d\theta}{\cos i} \quad (4)$$

From eq. (1) and (2), we have

$$\sin \beta = \sin (K-1)\theta \cos i + \cos (K-1)\theta \sin i \quad (5)$$

By substituting eq. (5) and (4) into (1), we get

$$\frac{d\phi}{d\theta} = \frac{2\pi}{\lambda} \left\{ r \sin (K-1)\theta - [1 - \cos (K-1)\theta] \cdot \frac{dr}{d\theta} \right\} \quad (6)$$

III. Formulas for Aperture Phase of Feed Planar Phased Array

In the previous section, we assumed that the electromagnetic wave was emitted from the center of the array and considered that the dimension of the feed array is much smaller than that of the lens. This is correct in the derivation of formulas for the fixed phase delay case. In reality, however, the passive lens depends on the antenna element to generate the wave. If the lens is located in a highly focused beam, then the radiated area is too small to form a secondary wave. In order to expose more area of the lens, it must be placed near the feed array. Because the index of refraction of the lens differs from point to point, it is not possible to form a beam in the k_0 direction if we still use a linear phase distribution as that for the scan angle of a planar feed array beam. A non-linear phase compensation will have to be added. Let us now analyze the situation from the angle of a receiving array^[2]. As shown in Figure 4, it is the sectional curve of any arbitrary surface of revolution and there is a phase delay only latitude-wise. The magnitude is determined by eq. (6).

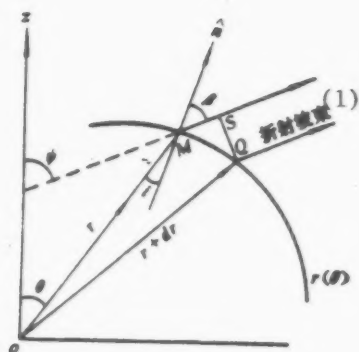


Figure 3. Geometry of Surface of Revolution Array Lens

Key:

1. refracted beam

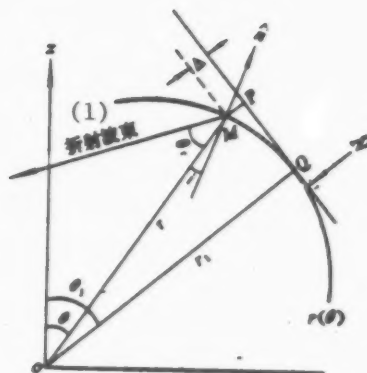


Figure 4. Coordinate to Calculate Feed Array Aperture Phase

Key:

1. refracted beam

From the path difference from the wave front to the curved surface

$$\Delta = (r - r_1) \cdot \hat{N} \quad (7)$$

where r_1 is the radial vector at the intersect between the curved surface to the wave front, r is the radial vector at any point on the curved surface and $\hat{N}$ is the unit vector in the direction of propagation, we can determine the phase difference caused by this path difference

$$\phi = \frac{2\pi}{\lambda} (r - r_1) \cdot \hat{N} \quad (8)$$

In order to determine the path difference, it is necessary to find the coordinate for the intersect (θ_1, ϕ_1) . If the curved surface is expressed by the following equation

$$r = x(\theta, \phi) \hat{i} + y(\theta, \phi) \hat{j} + z(\theta, \phi) \hat{k} \quad (9)$$

then the components of the normal vector at any point on the axes of a rectangular coordinate are:

$$n_x = \begin{vmatrix} \frac{\partial y}{\partial \theta} & \frac{\partial z}{\partial \theta} \\ \frac{\partial y}{\partial \varphi} & \frac{\partial z}{\partial \varphi} \end{vmatrix}, \quad n_y = \begin{vmatrix} \frac{\partial x}{\partial \theta} & \frac{\partial z}{\partial \theta} \\ \frac{\partial x}{\partial \varphi} & \frac{\partial z}{\partial \varphi} \end{vmatrix}, \quad n_z = \begin{vmatrix} \frac{\partial x}{\partial \theta} & \frac{\partial y}{\partial \theta} \\ \frac{\partial x}{\partial \varphi} & \frac{\partial y}{\partial \varphi} \end{vmatrix} \quad (10)$$

The unit normal vector is $\hat{n} = \frac{n_x + n_y + n_z}{\sqrt{n_x^2 + n_y^2 + n_z^2}}$ (11)

Then, we make $\hat{n} = \hat{N}$ to obtain (θ_1, φ_1) . Hence, the radial vector r_1 at the intersect could be determined to find the phase ϕ at any point on the curved surface.

According to the principle of electromagnetic wave propagation, the direction of the beam (which is the direction of phase gradient) is perpendicular to the phase plane in a homogeneous medium. Because the phase is distributed on a curved surface, the gradient is also calculated based on surface parameters. In a spherical coordinate with a surface of revolution, the components of the gradient are in the directions of $\hat{n}$, $\hat{\theta}$ and $\hat{\varphi}$. Let us make the fixed phase determined by eq. (6) be ϕ_1 and that from eq. (8) be ϕ_2 , then the phase distribution function of each antenna element is $\phi_1 + \phi_2$. In order to determine the direction of the beam, we attempted to find the gradient of the above phase function.

$$\left. \begin{aligned} \Gamma_\theta &= \frac{1}{2\pi} \frac{\partial}{\partial \theta} (\phi_1 + \phi_2) \\ \Gamma_\varphi &= \frac{1}{2\pi r \sin \theta} \cdot \frac{\partial}{\partial \varphi} (\phi_1 + \phi_2) \\ \Gamma_n &= \sqrt{1 - \Gamma_\theta^2 - \Gamma_\varphi^2} \end{aligned} \right\} \quad (12)$$

In order to find the path length from a point on the surface to the intersect, components of the gradient in the rectangular coordinate are obtained. They are

$$\left. \begin{aligned} \alpha_x &= (\Gamma_n \cos i + \Gamma_\theta \sin i) \sin \theta \cos \varphi \\ &\quad + (\Gamma_n \cos i + \Gamma_\theta \sin i) \cos \theta \cos \varphi - \Gamma_\varphi \sin \varphi \\ \alpha_y &= (\Gamma_n \cos i + \Gamma_\theta \sin i) \sin \theta \sin \varphi \\ &\quad + (\Gamma_n \cos i + \Gamma_\theta \sin i) \cos \theta \sin \varphi + \Gamma_\varphi \cos \varphi \\ \alpha_z &= (\Gamma_n \cos i + \Gamma_\theta \sin i) \cos \theta - (\Gamma_n \cos i + \Gamma_\theta \sin i) \sin \theta \end{aligned} \right\} \quad (13)$$

Let us assume that a beam is reflected at M whose coordinates are

$$x_M = r \sin \theta \cos \varphi, \quad y_M = r \sin \theta \sin \varphi, \quad z_M = r \cos \theta \quad (14)$$

The equation of reflected beam is

$$\frac{x-x_M}{a_x} = \frac{y-y_M}{a_y} = \frac{z-z_M}{a_z} \quad (15)$$

The intersect of this straight line with the feed planar array (assuming it coincides with the xoy plane) can be determined by letting $z=0$. Therefore, the coordinates for the intersect are

$$\left. \begin{aligned} x_s &= r \left[\sin \theta \cos \varphi - \frac{a_x}{a_z} \cos \theta \right] \\ y_s &= r \left[\sin \theta \sin \varphi - \frac{a_y}{a_z} \cos \theta \right] \\ z_s &= 0, \quad z_M \text{ see eq. (14)} \end{aligned} \right\} \quad (16)$$

The length between the point of refraction and the intersect is

$$L = \sqrt{(x_s - x_M)^2 + (y_s - y_M)^2 + z_M^2} \quad (17)$$

The phase caused by this path is $\phi_3 = 2\pi L/\lambda$. Thus, the total phase at the aperture in the planar array from the reception point of view is

$$\phi = \frac{2\pi}{\lambda} (L + \Delta) + \phi_1 \quad (18)$$

When the array is used as a transmitting antenna, the negative value of eq. (18) should be used in order to form a focused beam in the ψ direction.

IV. Dielectric Type Lens Antenna

The phase delay in a lens array may be achieved by changing the thickness of the dielectric lens. As shown in Figure 5, let us assume that the wave is emitted from the origin o and is deflected at an angle by the lens. The angle

between the beam and the z-axis is amplified from θ to ψ . Because the lens is assumed to be spherical, there is no refraction. By applying the law of refraction to the lens and from eq. (2), we get

$$\eta \sin i = \sin [i + (K-1)\theta] \quad (19)$$

where μ is the index of refraction of the medium. After expanding the above equation, we get the following differential equation based on eq. (3):

$$\frac{dr}{r} = \frac{\sin (K-1)\theta d\theta}{\eta - \cos (K-1)\theta} \quad (20)$$

By integrating eq. (20) with the initial condition: $\theta=0$ and $r=R$, we get the equation of the exit surface of the lens.

$$r = \frac{R}{(\eta-1)^{1/(K-1)}} [\eta - \cos (K-1)\theta]^{1/(K-1)} \quad (K \neq 1) \quad (21)$$

Lenses of different magnifying factors may be designed by choosing a different constant K .

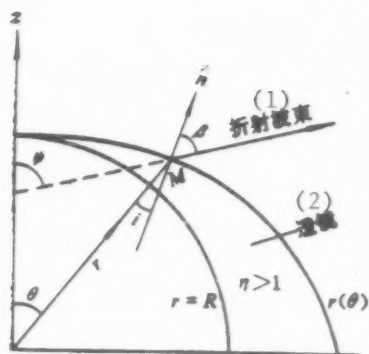


Figure 5. Dielectric Lens

Key:

1. refracted beam
2. lens

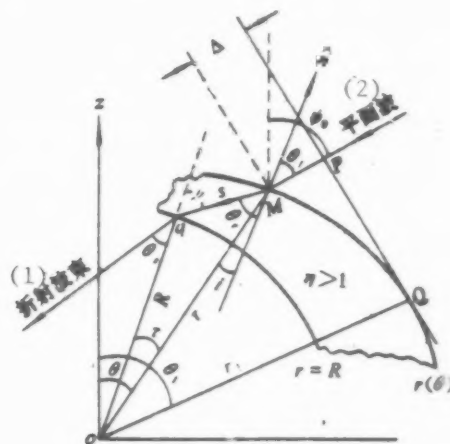


Figure 6. Schematic Diagram of Aperture Calculation of Cylindrical Dielectric Feed Array

Key:

1. refracted beam
2. plane wave

V. Calculation of Aperture Phase in Cylindrical Dielectric Lens Feed Arrays

Let us determine the angular relationship based on Figure 6. We are still looking from the viewpoint of a receiving array. Let us assume that the incoming wave is planar, it propagates at an angle ψ_0 with respect to the z-axis and i is the angle between the radial vector of the emerging surface and the normal i direction. From Figure 6 we know that the incident angle is:

$$\theta_i = \psi_0 + (i - \theta) \quad (22)$$

The angle of refraction can be obtained based on the law of refraction:

$$\theta_r = \sin^{-1} \left[\frac{1}{\eta} \sin \theta_i \right] \quad (23)$$

According to the relation of an arbitrary triangle oMq : $r/\sin(\pi - \gamma) = R/\sin(\theta - i)$ we get

$$\gamma = \sin^{-1} \left[\frac{r}{R} \sin(\theta - i) \right] \quad (24)$$

With respect to the incident surface of the lens, r is the incident angle. Therefore, the angle between the refracted beam and the radial vector of the inner surface of the lens is

$$\theta_r = \sin^{-1} \left[\frac{\eta r}{R} \sin(\theta - i) \right] \quad (25)$$

In order to determine the entire path length from the incoming wave plane to the aperture of the feed array, we must calculate three length segments, i.e. the path difference from the wave front to the exit surface of the lens, the distance s from M to q and the distance L from q to the feed array. Δ can be determined based on the following formula. First, let us find the tangential angle θ_1 .

$$\Delta = r_1 \cos(\psi_0 - \theta_1) - r \cos(\psi_0 - \theta) \quad (26)$$

where r_1 is the length of the radial vector at the intersect. s can be found based on the relation of the triangle OMQ

$$s = \sqrt{r^2 + R^2 - 2rR \cos \tau} \quad (27)$$

where $\tau = \gamma + i - \theta_{r_0}$. The formula for L is

$$L = R \cos(\theta - \tau) / \cos(\theta + \theta_{r_0} - \tau) \quad (28)$$

After the direction of the incident wave ψ_0 is known, the above formulas can be used to calculate the path differences. The total phase can be obtained by using a point to point method

$$\Phi = \frac{2\pi}{\lambda} (\Delta + \eta s + L) \quad (29)$$

With respect to the feed array coordinate

$$x = R \cos(\theta - \tau) \cdot \operatorname{tg}(\theta + \theta_{r_0} - \tau) - R \sin(\theta - \tau) \quad (30)$$

we are able to obtain a phase distribution in the feed array as a function of x .

With respect to a discrete curved array, the fixed phase of each antenna element in the formulas given in Sections 3 and 4 shall have the value in its corresponding coordinate.

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REFERENCES

1. USP: 37J5815, 1973.
2. Xiang Zhengping, Analysis of Dome Antenna, XIANDAI LEIDA [MODERN RADAR], Vol 2, No 6, 1980.

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APPLIED SCIENCES

INTRODUCTION TO REAL-TIME DISTRIBUTED COMPUTER NETWORK SOFTWARE

Beijing JISUANJI XUEBAO [CHINESE JOURNAL OF COMPUTERS] in Chinese Vol 7, No 1, Jan 84 pp 1-9

[Article by Cao Dongqi [2580 2639 0796], Institute of Computing Technology, Chinese Academy of Sciences: "Overall Design of RDC Network Software"; paper received 23 November 1982]

[Text] Abstract: RDC-net (Real-time Distributed Control network) is an experimental computer network with real-time distributed control and resource-sharing. It is built in two-level structure and distributed configuration. A survey of the scheme of RDC network software development is given in this paper. The work in the first phase of the project is also briefly described.

The Real-time Distributed Computer Network (RDC Net, for short) is an experimental computer network designed in two-level structure and distributed configuration for real-time distributed control and resource sharing. After its construction it can support many large, medium, mini, and microcomputers and through many means of communication form a network in any topological configuration for data communication and resource sharing, provide distributed processing and real-time control functions, and depending on the needs of users, be used in such fields as information transmission, data processing, process control, information retrieval, enterprise management, and military command. The development of RDC Net software was a large-scale software project. The overall development plan was called the RDCP plan and was divided into three phases, called RDCP1, RDCP2, and RDCP3. This article is devoted to the overall conception of RDCP and a general picture of RDCP1 network software. The following six articles in this issue will deal with the six network software systems developed in the first phase of the project.

I. Overall Conception of the RDC Network

1.1. Network Configuration

Depending on the physical conditions of manpower, time, and equipment, the RDC network will be constructed on the principle of from small to large, and from base levels to upper levels. Figure 1 sketches the RDCP1, RDCP2, and RDCP3 network configurations. These configurations are upwardly compatible and expandable. It is easy to expand the RDC network scale in a planned and

measured way, to improve and perfect network functions, and to expand the network's range of applications.

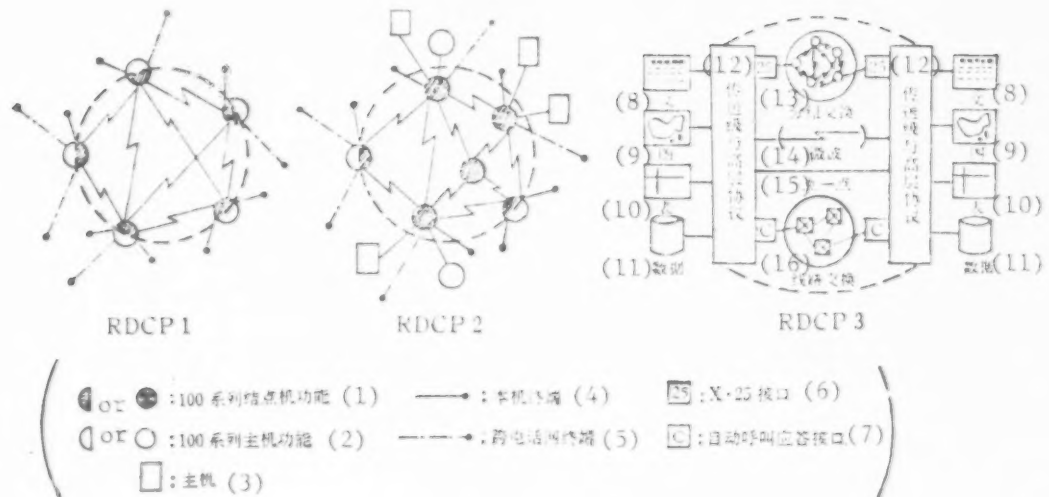


Figure 1. Diagram of Network Structure in Each Phase

Key:

- | | |
|---|---|
| 1. 100 series node computer function | 9. Graphic |
| 2. 100 series host computer function | 10. Chart |
| 3. Host computer | 11. Data |
| 4. Local computer terminal | 12. Transport level and higher level protocol |
| 5. Crossover telephone network terminal | 13. Packet exchange |
| 6. X.25 interface | 14. Microwave |
| 7. Automatic call-respond interface | 15. Point-to-point |
| 8. Text | 16. Line exchange |

The characteristic features of the RDCP1 network configuration are: 1) Many D/S-100 series computers can be linked together in a network in any distributed configuration using communication lines; 2) in addition to assuming the functions of node computers, the 100 series computers in the network also have host computer functions; 3) the terminals in the network are simple terminals (for example, five-bit or seven-bit keyboard printer and keyboard display), they can be local terminals directly linked to the node computer and they can also be remote terminals linked to the node computer by the telephone network. The 100 series computers were selected as the node computers and host computers of RDCP1 because current domestic output is high, they are the most widely used, and the software system analysis is very clear. This choice will help us get the fastest results possible and presents a large ground for promoting applications. With the development and maturation of other domestically produced computers, when necessary, adding or shifting to more suitable computers as node computers may be considered.

The main characteristic features of the RDCP2 network configuration is the resolution of three interface problems on the basis of the RDCP1 network configuration, i.e., interfacing with large and medium host computers or high grade 100 series computers, interfacing with microcomputers and Chinese character terminals, and changing the asynchronous communications interface between node computers to a synchronous interface. In RDCP2, the 100 series computers can function independently as node computers and host computers or have two functions at the same time. When this part of the project is completed, the RDC network will form a two-level computer network of preliminary scale. That is, it will be made up of a reliable and highly efficient communications subnetwork and a well equipped and full function resource subnetwork.

The characteristics of the RDCP3 network configuration is that the problem of diversification upward and downward is resolved. The aim of downward diversification is to make the RDC network a communications subnetwork that can adopt many available communications methods, provide reliable and efficient communication for higher levels, and can adapt to the demands of different applications. For example, in addition to adopting the X.25 packet exchange, adoption of such communications methods as direct point-to-point links, line exchange, microwave communications, and communications satellites may also be considered. The aim of upward diversification is to permit many resources to join the network and support many network applications. For example, to adapt to applications demands in such areas as graphics, mapping, Chinese character processing, and list processing, RDCP3 should permit connecting the relevant equipment, formulating the relevant network protocols, and writing the relevant software system (such as text, graphics, and spreadsheet processing systems).

1.2. Network Protocol Levels

The RDC network includes two basic entities; one is the user and the other is the resources. The user communicates directly or indirectly in some dialogue form with the user interface which carries out the assigned task on behalf of the user; the resources, interfaced with a specific resource (including hardware resources, software resources, and data resources) provides the relevant service to the user. Generally speaking, the entities in the network communicate with each other and interact according to network protocols. A protocol means the arrangement which must be observed when a dialogue is carried out between specific entities and is ordinarily made up of syntax, semantics, and exchange rules. The RDC network protocol adopts the level structure as illustrated in Figure 2. It is worked out in interconnected modules according to the ISO development system and on the basis of our specific circumstances. To be specific, they are made up of seven protocols: physical level, link level, network level, transport level, meeting level, expression level, and application level, whose functions are generally described below:

First level (physical level): The physical connection between data link entities. RDCP1 is temporarily using asynchronous communications interfaces to link with the 100 series computers. Later RDCP2 will use synchronous interfaces.

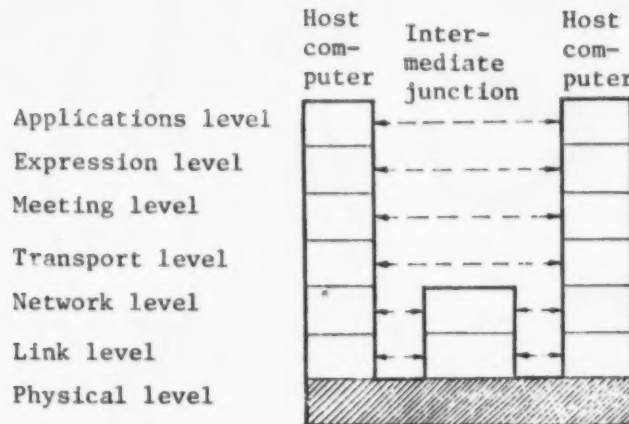


Figure 2. RDC Network Protocol Level Model

Second level (link level): Error-free data transmission between neighboring node computers. Uses CCITT X.25 non-equalized link access protocol (LAP) and the equalized link access protocol (LAPB).

Third level (network level): Provides transport level with set up, maintenance, and remove network connect functions and data transmission and control functions. The second period project uses CCITT X.25 packet level protocol; RDCP3 will consider adding line exchange and other communications methods.

Fourth level (transport level): Achieves end-to-end connections independently of basic network communications, provides process-to-process communications for different processes on the computer systems in the network, and maintains clear data transmission between them. It uses the internetwork end-to-end transport protocol proposed by ISO.

Fifth level (meeting level): Supports interaction between cooperating application entities. Control functions provided include control of set up, discrimination, and removing of meeting relations between application entities and synchronous control and boundaries of data exchange, to help ensure that safe, reliable, and orderly dialogue can be conducted between application entities. There are three types of meeting form: unidirectional, staggered bidirectional, and simultaneous bidirectional.

Sixth level (expression level): This level provides an overall formatted service to help applications level entities analyze and interpret the content and meaning of the data exchanged. The typical expression level protocols include dumb terminal protocol, file transmission protocol, remote job entry protocol, and electronic mail protocol. They are responsible for the coordinated management of various operations which include recording, exchange, storage, search, display and control of various data structures.

Seventh level (applications level): This level consists of the various types of applications systems and the user-written programs. They can call up the

various network service functions through software at the expression level. As far as the range of applications is concerned, this level has a wide range and number of protocols used for supporting network resource sharing, typical task activity, specific enterprise management, and safe operation of network applications systems.

Of these seven levels, levels 1-3 constitute the network communications service level, levels 5-7 constitute the network applications service level and the fourth and transport level links these two groups of levels together. One of its important functions is to choose the optimum communications service method for carrying out relevant network activity on the basis of the service demands and parameters of the network applications service level.

1.3. Principles of Writing Network Software

In the RDC network software development process, we decided on principles of simplicity, practicality, reliability and effectiveness and on this basis tried to make the system expandable and to make it possible to delete elements so that it would be more adaptable. For this reason, in the software system structure we adopted design method by levels, modules, and processes, and planned to produce a system which would make the network software easy to edit and expand to adapt to the function demands and differences in resources and equipment of the various stations and to the developments and changes of each phase of the project. The overall functions of the RDC network are implemented through various network protocol software and network applications systems. Network protocol software was developed by levels from bottom to top taking the seven network protocol level models as natural levels. Between all the levels there is a partially ordered unidirectional dependency relationship in which each level is related only to neighboring levels: the lower level is the foundation of the upper level and provides services to the upper level; the upper level is implemented through functions supplied by the lower level and for the higher level provides functions which are more powerful. There is a clear interface relationship stipulated between level and level and when a level is expanded or revised, as long as the interface relationship is not changed, the functions and structure of the other levels are not affected. Generally speaking, each level is made up of a module with unitary functions, clear interface, and moderate size and they cooperate among themselves through a unified form of transfer and communications. Each module in a level usually can also be further subdivided into a certain number of levels for editing in accordance with the transfer relationship. One important characteristic of network activity is the high degree of coincidence. To ensure this coincidence, the network protocol software or network applications system of each level in the RDC network is implemented through one or many processes.

II. General Picture of RDCPl Network Software

RDCPl network software was developed on the DJS-100 series computers and includes link level software, packet level software, transport level software, packet assembly/disassembly software, mini relational data base system and remote job entry system. The first four systems were designed in accordance with the four lowest protocol levels in protocol level model or relevant

international standards. Taken together they make up a network communications service level which has stable functions. The last two systems are the two network applications systems. They operate under the support of the first four systems. Since there are no functions which independently provide higher level network protocols in the first phase of the project, the latter two systems have some simple and necessary meeting level and expression level functions. Figure 3 gives the positions occupied by the six systems in the network level model.

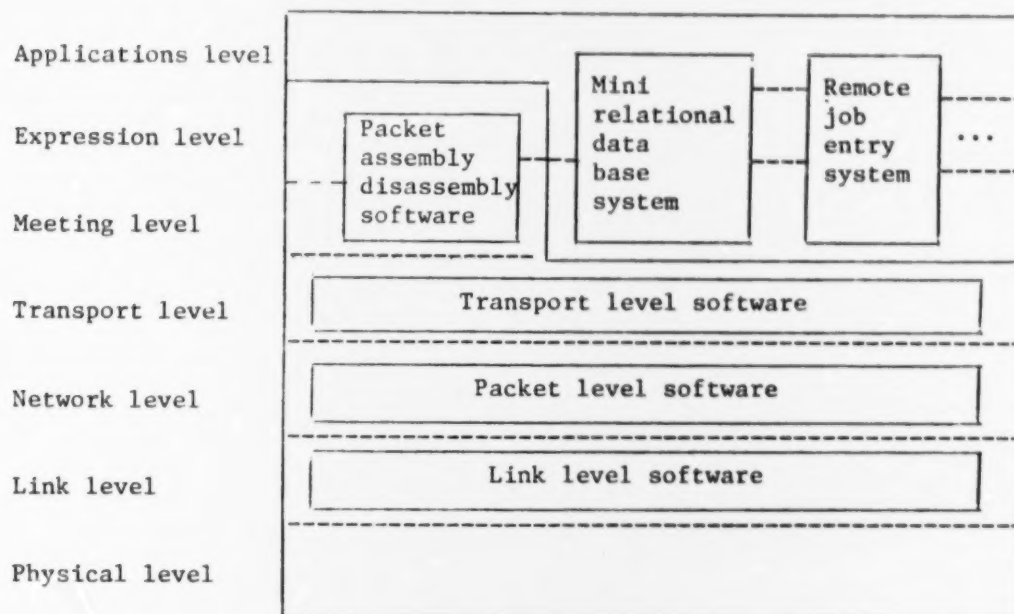


Figure 3. RDCPl Network Software by Levels

So that the user will have the vigorous support of the RDOS system when developing new network applications, we decided on a policy of developing six network software systems under the support of the RDOS system and making them subsystems under the control of the RDOS system. However, to adapt to the network environment, we also made some necessary revisions and expansions in the RDOS system. Below we will first introduce the revisions and expansion of the RDOS system, then reintroduce separately the four network protocol software and two network applications systems.

2.1. RDOS System Revisions and Expansions

As stated above, RDCPl network software was developed under the support of the RDOS system. Specifically, utilizing the multi-task management functions of the RDOS system to support communications, and synchronous and coincidental operations between many processes; carrying out the necessary file operations through the various functions provided by the system used by the call command

in the RDOS system; executing exchange and link commands to cut between systems within the network software; establishing timed or time-delay tasks to implement time control and carry out cyclical work. However, to adapt to the work characteristics of the network environment, so that the network software manages communications control and data transmission by itself, to implement various types of communications control rules, and to lighten the work volume of the upper level network protocols and the network applications system, we made the following revisions and expansions to the RDOS system.

- (1) Revised the QTY drive program to add a call-respond module.

To support link level protocol between DJS-100 series computers and to support communications between the terminals by the network software and computers, and for basic transmission control rules between the computer and long-distance telephone network terminals, we changed the QTY asynchronous multiplex communications controller into a corresponding user defined device and self-editing interrupt processing program. In addition, we also added a call-respond module for timed task operations to monitor and manage the telephone line call bell signal and carrier signal of the communications process.

- (2) Added a queue management function.

To facilitate using a method of registering processing units between processes for requests back and forth and to implement mutual communication and cooperation, we added a processing unit queue for each process in the network software and provided the three queue primitives PUT, GET, and GETS (see Table 1).

- (3) Added buffer management functions.

To support the user program and network software transmitted data and implement network protocol, buffer management functions were added to the foundation of the RDOS system. Buffers are divided into large and small: each 40-digit long large buffer is used for transmitted data; each 10-digit long small buffer is used for transmission protocol commands. Correspondingly, the primitives AG, AL, and RL (see Table 1) were provided so that the user could flexibly use and manage the relevant buffer.

- (4) Exclusive operational primitives.

To implement mutual exclusion between processes, we introduced N access values as an 0 or 1 signal volume, written as S1, S2, ..., SN and provided the two operational primitives PS and VS. Actually, the value of the signal volume reflects the user situation of the resources: when the value is 1, it means they are already occupied; when the value is 0 it means that they are not yet occupied. Thus, in terms of processes competing for resources, the mutual exclusion function will be achieved if a PS operation is carried out before entering the stage of mutual exclusion and a VS operation is carried out on withdrawing from the stage of mutual exclusion.

Table 1. Network Software Expansion Primitives and Their Functions

<u>Class</u>	<u>Primitive</u>	<u>Functions</u>
Queue manage- ment	PUT(P,M)	Combines the number of the process called by the primitive and the information content M, registers it in the process queue of the designated process P. If the queue is empty when the process is registered, then it will activate the corresponding receiving process P.
	GET	Calling the process of this primitive the first process unit is taken from its own processing unit queue so as to carry out the corresponding process in the service request issued. If the process unit queue is empty an error is returned and the caller processes it by itself.
	GETS	Similar to the GET primitive but differs in that if the process unit queue is empty, it does not return an error but registers the process called by the primitive until another process is sent by a PUT primitive at which time it is reactivated and continues work.
Buffer manage- ment	AG(A,S)	Requests a large buffer. If there is a buffer that can be provided, after the return in status S indicates that there is a buffer and in A gives the first address in the buffer assigned. If there is no buffer, it is so indicated in status S.
	AL(A,S)	Functions similar to AG but requests the assignment of a small buffer.
	RL(A)	When the buffer is no longer needed, this command can be called to release the buffer at the address indicated by A.
Dis- mantling operations	PS(SEM)	Determines whether the value of the corresponding signal SEM is 0: if the value is 0 then the signal is set to 1, then it returns and continues execution; if the value is 1, then the process called by this primitive is registered in the corresponding signal queue.
	VS(SEM)	Sets corresponding signal to 0 and if the signal's queue is not empty, then activates the process to which it is registered.

P = expression process signal; M = expression information content; A = expression buffer address; S = expression buffer distribution; SEM = expression signal number.

2.2. Network Protocol Software

RDCP1 network protocol software is made up of link level software, packet level software, transport level software and packet assembly/disassembly software. In view of the fact that we hope to be able to operate with the support of low grade 100 series computers and a simple operating system in order to give them a broader range of application and support multiple network applications systems and user programs, when we wrote this protocol software, we used assembly commands as much as possible and used few high level operation system commands. Below is a brief introduction to these protocol software functions and their makeup.

(1) Link Level Software (LL)

This software was implemented in accordance with the CCITT X.25 link level protocol and the basic rules of ISO with revisions made on the basis of specific situations. It is situated above the physical level and is the basic protocol software of the lowest level in the network level model. It is primarily composed of the interrupt module, computer link management module, and the terminal link management module. The interrupt module is responsible for managing the information transmitted on the communication lines and its control. The computer link management module supports error-free transmission between neighboring computers and carries out HL, a link level protocol similar to the CCITT X.25's. And, the terminal link management module supports communication between terminals and computers and is responsible for carrying out BL, the basic transmission control rules between remote terminals and the computers.

(2) Packet Level Software (PL)

This software carries out CCITT X.25 packet protocols: it reuses the data links provided by the link level and provides virtual circuit service between two DTE's. In the process of setting up virtual circuits, the packet level software uses the fixed routing method to select the network path. After a virtual circuit has been set up, it is responsible for managing the transmission of data packets and interrupt packets, executing flow control, reset, and restart functions up until the data transmission stage is concluded and the virtual circuit is disconnected.

(3) Transport Level Software (TS)

The transport level software, in line with the internetwork end-to-end protocols proposed in IFIP WG 6.1, selected this subset to implement RDC net transport level protocols with the aim of providing communications functions between processes on the net. This software establishes many xinkou [0207 0605], manages correspondences between them and the user processes, and on the foundation of the virtual circuits provided at the packet level, sets up, maintains or closes the links between xinkou, depending on user requests, transmits data or telegrams over the link, and can cut to another xinkou on an already established link.

(4) Packet Assembly/Disassembly Software (PAD)

This software carries out the functions stipulated in CCITT X.3 and X.28 proposals with the aim of permitting simple terminals (such as keyboard printer terminals and keyboard display terminals) to enter the net and to implement the mutual transfer between terminal input/output character flow and transmission packet flow within the net. Based on instructions issued by the end user it can set up, reset, or remove connections between the terminal and the corresponding service program, transmit data information or interrupt information, and display or revise terminal specific data (such as whether or not a filler character should be added after the longest line or a CR).

Figure 4 illustrates the data flowchart and command flowchart between the above-described network protocol software. In the data flow, when the data information issued by the user process or terminal operator goes through network protocol software from top to bottom levels, it should carry out in sequence transformation of character flow, message, interconnected packet sequence, independent packet sequence, and frame sequence; on the other hand, when information crosses over the communications network and goes through the destination network protocol software from bottom level to top level, it goes through the corresponding reverse conversion in sequence and is finally delivered to the user process or end user at the other end. In the control flow, the network service request required by the user process or end user is carried out by the conversion of the level commands PAD, TS, TS-PL, PL-LL and I/O or their reverse conversion.

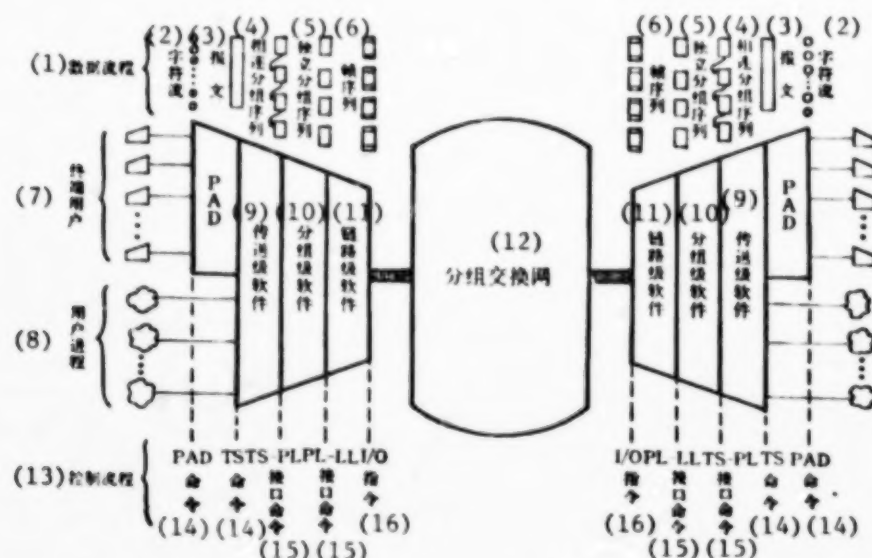


Figure 4. Data Flow and Control Flow Between Network Protocol Software

[Key on following page]

Key:

- | | |
|--------------------------------|-----------------------------|
| 1. Data flow | 9. Transport level software |
| 2. Character flow | 10. Packet level software |
| 3. Message | 11. Link level software |
| 4. Linked packet sequence | 12. Packet exchange net |
| 5. Independent packet sequence | 13. Control flow |
| 6. Frame sequence | 14. Command |
| 7. End user | 15. Interface command |
| 8. User process | 16. Instruction |

2.3. Network Applications System

After the four network protocol software described in 2.2 above were set up, we created a network communications service level with stable functions and flexible application. Under its support, the user or system designer can conveniently design or write user programs which involve network activity and develop a variety of network applications systems. This is because, in the RDCPl network software, in addition to maintaining the powerful support of the original RDOS system for user programs, the two new powerful supports of the transmitting station command and the PAD command were added for the user (see Figure 5). In short, when the user program requires network activity, through the transmitting station command it can conveniently call any program on any computer in the network and communicate and cooperate with it and jointly complete the necessary task (see Figure 5, item 1); when the user program provides network service for the end user, the end users can use the PAD command through various terminal equipment to simultaneously request the network service provided (see Figure 5, item 2); when the user program requires management resources, development work or to call on relevant files, it can use the powerful support of the RDOS system directly (see Figure 5, item 3). As an example of the actual applications value, the RDCPl developed two network applications systems: a mini relational database and remote job entry system. They are briefly described below.

(1) Mini Relational Database System (MRDS)

This is a mini relational database system under the network environment. It consists of a network on-line search subsystem and a data base manager subsystem. The former is designed for the network user and can simultaneously support many user searches of relevant content of the database. The search command is commonly a combination of select, project, and join operations. The latter is designed for the data base manager for ordinary maintenance and management of the database. It is a single-user system for a non-network environment, and can be used for setting up, loading, revising, and deleting relational patterns and their values in the database. With the support of the network communications service level, if a large database is suitably divided into so many mini databases and rationally distributed in the network, then a distributed database function based on the small base as the distributed unit can be implemented.

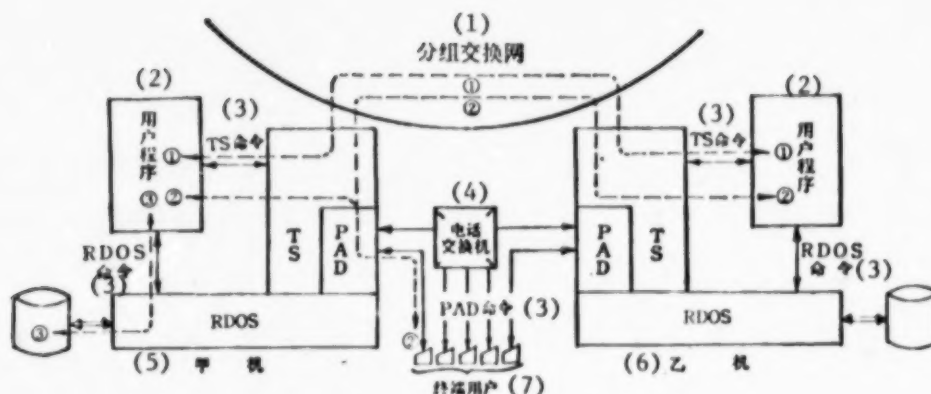


Figure 5. Support Functions of RDCPl Network Protocol Software

Key:

- | | |
|------------------------|----------------------|
| 1. Packet exchange net | 5. Computer A |
| 2. User program | 6. Computer B |
| 3. Command | 7. Terminal operator |
| 4. Telephone exchange | |

(2) Remote Job Entry System (RJE)

This system consists of account opening subsystem, operations monitoring and control subsystem, job entry subsystem, and batch processing system. The account opening subsystem is designed for the system managers and is used for opening accounts, closing accounts, statistics, collecting fees, and creating passwords. The operations monitoring and control subsystem was designed for the system operators and is used in monitoring the system operations situation and controlling system startup and stop and operations of the cutting job entry subsystem or batch processing system. The job entry subsystem is a multiuser system under a network environment and can support many network users simultaneously submitting their own jobs or requesting the results of a previous job entry from different stations in the network. The batch processing system is an original subsystem of the RDOS system but it is included under the control of the operations monitoring and control system to execute the job to be entered during the entry phase or save the operational results of the job. This phase is called the execution phase and is done under a non-network environment.

III. Conclusion

This paper has introduced the general concepts of the RDC network software development and a general picture of RDCPl network software. RDCPl development plans are made up of gradual revisions, expansions and improvements. The present RDCPl has been completed, RDCP2 is just beginning, and RDCP3 is still only in outline. The network software developed in the first period will be further revised and perfected in actual application and we will strive to make it more practical and improve the efficiency of operation.

Some aspects of the conceptions of the second and third periods also will undergo necessary adjustments, revision, improvements and expansions in the process of being used and the key technologies also await further discussion and resolution.

RDCPl network software was jointly developed by the comrades of the "Network Software and Database" group of the Institute of Computing Technology of the Chinese Academy of Sciences and over 10 graduate students who were pursuing studies in the group at the time. In the development process, Comrade Ma Yinglin [7456 1758 3829] provided many beneficial ideas for the overall plan and proposed the overall conception of the functions, structure and implementation of the remote job entry system; Comrades Xu Caijie [1776 2088 2638], Gao Jianyu [7559 0494 1342], Xu Zhuanyou [1776 0278 0645], and Xu Xiaqing [6079 7209 0615] and Comrade Cao Zhijiang [2580 0037 3068] did a great deal of the hardware transformation work and communications interface work for the development of the RDCPl network software; many comrades of Digital Control Lab 1, Digital Control Lab 4, and NOVA3 Computer Lab provided us with vigorous support and enthusiastic assistance and also provided us with an excellent working environment. On behalf of the authors of the following six articles, the author would like to take this opportunity to express heartfelt thanks to all these comrades and the comrades who gave engineering support to this project.

REFERENCES

1. ISO, Reference model for open systems interconnection, International Organization for Standardization, DP 7498.
2. ISO 1745-75, ISO 3309-79, ISO 4335-79, International Organization for Standardization.
3. CCITT Provisional recommendations, X3, X25, X28, and X29 On packet-switched data transmission services, International Telecommunications Union, Geneva (1978).
4. V. Cerf, A. McKenzie, R.A. Scantleburg, and H. Zimmerman, Proposal for an internetwork end-to-end transport protocol, IFIP, WG 6.1 (1978).
5. Cao Dongqi [2580 2639 0796], Liu Fuzi [0491 4395 3320], JISUANJI WANGLUO RUANJIAN JICHU [COMPUTER NETWORK SOFTWARE FOUNDATION], People's Posts and Telecommunications Publishing House, 1982, 7.
6. UNINETT Reports, No 1-5, Oslo.
7. D.W. Davies, D.L.A. Barber, W.L. Price, and C.M. Solomonides, Computer networks and their protocols, John Wiley and Sons, 1979.

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APPLIED SCIENCES

LINK LEVEL PROTOCOL, ITS IMPLEMENTATION

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[Text] Abstract: The BL and HL communication protocols adopted in the link-level of RDC network are presented. Also included are the implementation of the link-level and its interface to other levels.

I. Overview

The RDC Net is an experimental computer network based on the Chinese-made DJS-100 series computer. It is divided into five levels and the link level is the basic software of the lowest level of the network. Its aim is to provide error-free data transmission between communication entities which are scattered geographically.

Currently, the RDC Net link level administers four kinds of circuits (see Figure 1). The first kind of circuit is used for linking local five-bit telecommunications equipment, the second kind of circuit is used for linking local seven-bit telecommunications equipment, the third kind of circuit is used for linking remote terminals over the Changsha City [changshi [7022 1579]] telephone network, the fourth kind of circuit is used to link the node computers in the network. The distances spanned by the first and second kind of circuits are rather short and transmissions between terminal equipment and the computer can be regarded as error free. The third kind of circuit goes over the changshi telephone network, and in the transmission process, the information is subjected to a great deal of interference, thus to eliminate this interference and ensure reliable information transmission, a basic level data communication protocol (BL) has been implemented on this type of circuit. The distances covered by the fourth kind of circuit are large and demand that simultaneous, bidirectional, and encoded data transmission can be carried out between computer and computer thus a high level data communications protocol (HL) has been implemented on this kind of circuit.

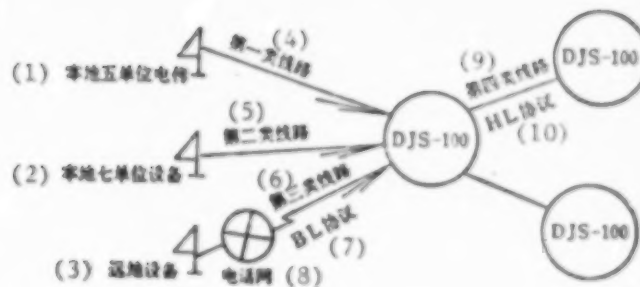


Figure 1. Connections of Various Circuits in RDC Net

Key:

- | | |
|--------------------------------------|---------------------------|
| 1. Local five-bit telecommunication | 6. Third type of circuit |
| 2. Local seven-bit telecommunication | 7. BL protocol |
| 3. Remote equipment | 8. Telephone network |
| 4. First type of circuit | 9. Fourth type of circuit |
| 5. Second type of circuit | 10. HL protocol |

II. Brief Introduction to the BL and HL Data Communications Protocols

1. BL Protocol

The BL protocol adheres to the stipulations of ISO document 1745 and CCITT proposal V.24. Its basic features are as follows:

- (1) The circuit connection method is point-to-point so the communications circuits can be dedicated circuits, leased circuits or public telephone exchange circuits. A modem is added at both ends of the public telephone exchange circuits or long-distance circuits.
- (2) The method of signal timing is local timing, also called asynchronous, i.e., the length of each code element in a character is identical, but the time interval between characters can be of any length.
- (3) The circuit work method is a full duplex circuit. At half-duplex voice transmission control transmission speed can vary between 200 and 9600 bit/sec.
- (4) The character set is the international number 5 code stipulated by the ISO and the CCITT. Except for 10 transmission control characters, the other characters can be user information transmitted in the system.
- (5) Error control is by cross parity check (see Figure 2). User information is expressed in a 7-bit code. Before transmission, one bit is added to each character as a parity check bit, and a block check character (BCC) is added after each group of information. At the receiving end, a parity check is done for each character and a horizontal parity check is done on each group of information. If no errors are discovered the blocks are considered correct; if an error is discovered then the transmitting terminal must retransmit that group of information.

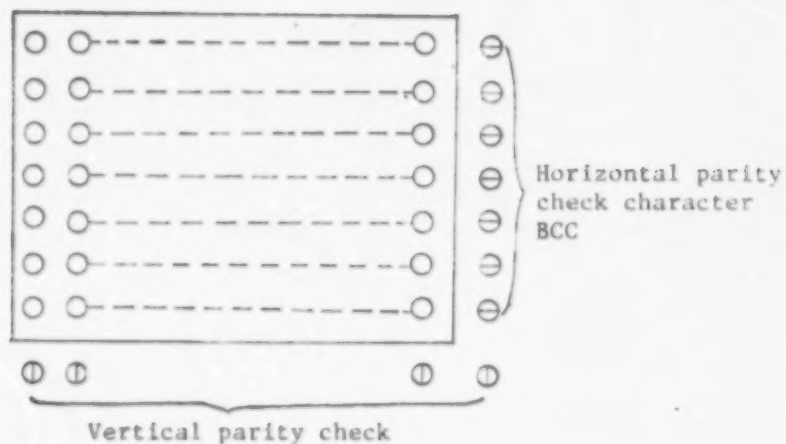


Figure 2. Cross Parity Check

(6) Flow control uses waiting type flow control; only after the first group of information has been received correctly can the next group of information be transmitted.

(7) The text format of information transmitted on the circuits is divided into two classes by function as information text or supervisory text. Information text is used for transmitting user data; supervisory text is used for transmitting control information and this control information is used for managing the process of data information transmission.

Information text format is as follows:

a	S	S		E	B
	T	T	text	T	C
	X	X		B	C

b	S	S		E	B
	T	T	text	T	C
	X	X		X	C

c	S	S		E	F
	T	T	text	N	N
	X	X		Q	Q

All of a user's data can be made up of a b-type text and can also be made up of some a-type text followed by a b-type text. The c-type text is invalid text and can appear in any position in user data flow.

Supervisory text is of the following types:

d	E N Q	selected station (SEL) (n = source station mark)	e	E E N N Q Q	enquiry station (ENQ)
f	E E O O T T	handing over right to transmit (αα)	g	D E L O E T	disconnect (DIS)
h	D L 0 E	acknowledge (ACK0)	i	D L 1 E	acknowledge (ACK1)
j	D N L A E K	negative acknowledge (NAK)	k	D L 5/12 E	pause (PSE)
l	D L 3/10 E	request right to trans- mit (ββ)	m	D L 4/14 E	group interrupt (BER)

From d to g are forward supervisory text, and g to m are reverse supervisory text.

(8) Communications stages and their connections. A complete data transmission process between a pair of users can be divided into five stages:

- a) Establishing connection on the public telephone network. The user uses an ordinary telephone for dialup and the telephone bureau handles switching and identification.
- b) Defining the data link. After the connection has been made on the public telephone network, if the unit has a switchboard, an additional switching operation has to be made to complete the circuit continuity process. Then, the party making the call becomes the primary station and issues the select sequence SEL; the party called becomes the secondary station and uses the ACK0 to indicate willingness to respond, then the data transmission sending-receiving relationship is defined.
- c) Data transmission. In this stage, the primary station transmits data, the secondary station gives the response; the functions of the primary station and secondary station do not change. The primary station transmits information text and if it is checked and correct, the secondary station alternately uses ACK0 and ACK1 to make affirmative response. If there are errors in the information text, the secondary station uses NAK for negative response; if the secondary station is temporarily unable to receive information text, it uses PSE to request that data transmission be stopped temporarily. When the primary station receives alternate affirmative responses it transports the next information text; when the primary station receives a negative response it transmits the current information text; when the primary

station receives a temporary stop response, it transmits an enquiry test; when the primary station does not receive a response after a certain time it also transmits an enquiry test; when the primary station continues to receive a negative response N times in a row or no response N times continuously after the time limit, it should be reported to the operator that there is a problem on the circuit.

d) Concluding data link. After data transmission has ended, the primary station sends an $\alpha\alpha$ text, giving up its primary station status and transfers the right to transmit to the other party. If the new primary station has a text it wants to transmit, then it returns to the third stage and carries on data transmission. If the station receiving the right to transmit does not wish to continue communication, it can transmit a DIS text cutting off the data link, then entering the fifth stage.

e) Breaking off the connection on the public telephone network. This stage is done by the telephone bureau. The process is identical to that of the ordinary telephone user breaking a connection.

2. HL Protocol

The HL protocol was designed in accordance with ISO document 3309 and ISO document 4335 and on the basis of the hardware support obtainable at the time. Its basic characteristics are as follows:

(1) Circuit connection method. Uses the point-to-point method. The communications circuits used may be dedicated circuits or leased circuits and for long-distance circuits modems must be used at both ends.

(2) Signal timing method. Partial timing method is used the same as with the BL protocol.

(3) Circuit work method. Uses four line full duplex circuit, carries out simultaneous duplex data transmission, transmission rate can vary between 200 and 9600 bit/sec.

(4) Character set. A bit string of any composition can be under the control of the HL protocol, from one node to another, but the length of the bit string must be an integer of multiples of 8.

(5) Error control method. Uses horizontal and transverse parity checking to check for errors in the transmission process (see Figure 3). Each frame transmitted includes a 16 bit frame check sequence of which the first 8 bits are horizontal check codes of information in the frame and the last 8 bits are transverse check codes of the information in the frame. At the receiving end, horizontal and transverse parity checks are done of the frame received and if there are no errors the frame is considered correct; if errors are discovered, the frame is discarded.

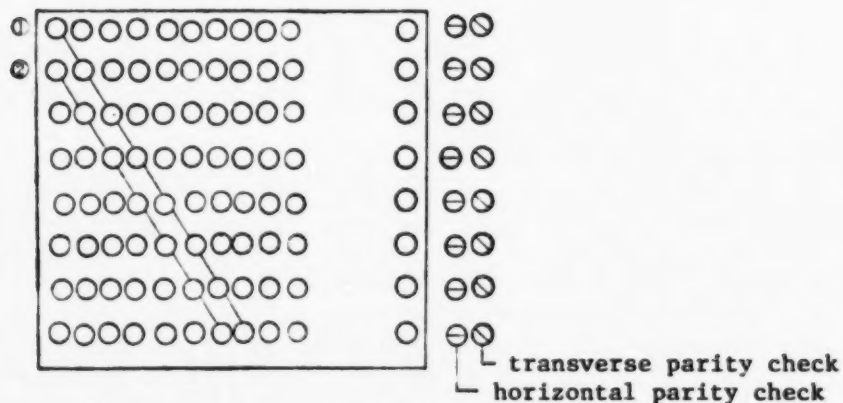


Figure 3. Horizontal and Transfer Parity Check

(6) Flow control method. Between two node computers there are simultaneously two data flows and two control flows, the control flow in one direction and the control flow of the other data flow control occupy one physical channel. Each data flow is transmitted only after the previous data frame has been correctly received.

(7) Frame format. Information transmitted on the circuit uses a uniform letter format whether it is an information frame transmitting user data or a supervisory frame transmitting control information it uses the following format:

F	L	C	I	FCS	F
---	---	---	---	-----	---

F is the flag sequence (0 11 11 11 0) and takes up one byte. L indicates the frame length in bytes and takes up one byte. C indicates the type of frame and takes up one byte. FCS is the frame check sequence and takes up two bytes. The information field I only appears in the information frame and can be less than or equal to 64 bytes in length.

(8) The communications process. After the system has been loaded, the physical links are in the on state. When a user in the upper level of the network pushes data which is to be transmitted over a circuit into the link level, the link level first of all sets up a bidirectional, asynchronous, balanced link, then shifts into the data transmission stage. In the data transmission stage, each station can independently transmit information frames in sequence and each time a frame is sent, the frame sequence is increased by 1. The receiving station ignores frames checked and with errors. If the sequence number in an information frame is the frame sequence number it wants to receive, it sends back a response frame that it is ready to receive. If the sequence number in the data frame is the sequence number of the previous frame, it also sends back a response frame that it is ready to receive, but discards the information frame received; if the sequence number in the information frame is another value, it sends back a refusal response frame;

if it is unable to receive the information frame, it sends back a response frame that it is not yet ready to receive. When the sender discovers that a certain time limit has been exceeded without a response, it retransmits the current information frame. When it has gone beyond the time limit N times in a row or when there have been N negative responses in a row, the operator is notified that there is trouble on the link. If the upper level of the network temporarily does not have sufficient data for the link to transmit, the link state is still maintained in the data transmission state, and only when the upper level on the network indicates that it wants to break off the data link does the link level disconnect the data link in question.

III. Implementation of the Link Level

The link level includes five processes, one interrupt module, two communications primitives and a group of circuit characteristics tables (see Figure 4).

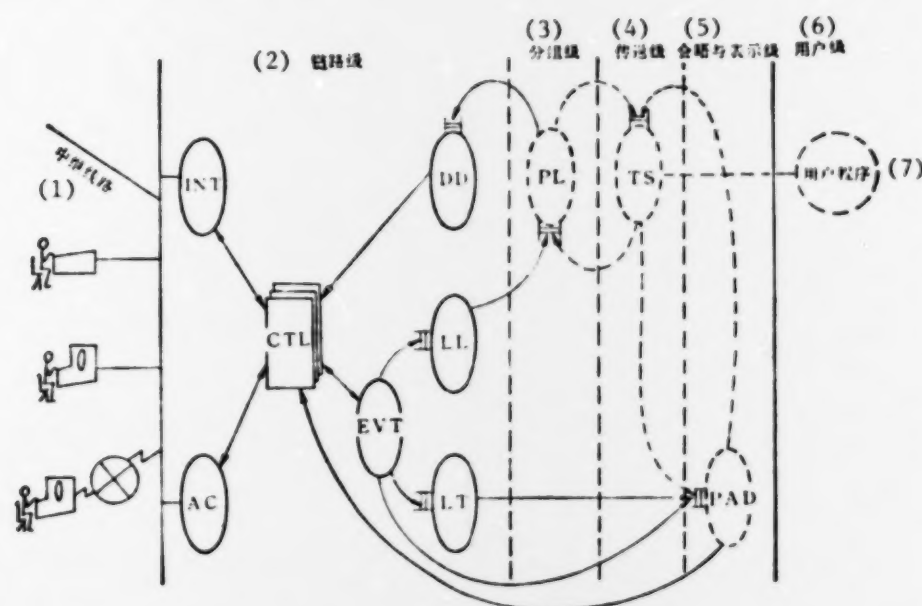


Figure 4. Make Up of Link Level

Key:

- | | |
|----------------------|----------------------------------|
| 1. Interrupt circuit | 5. Meeting and expression levels |
| 2. Link level | 6. User level |
| 3. Packet level | 7. User program |
| 4. Transport level | |

1. Circuit Characteristics Tables CTL

A circuit characteristics table CTL is set up for each external line (including links between the DJS-100 and a terminal and links between DJS-100's) in the link level. It records such information as circuit state, data queues on

the circuit waiting to transmit, and data fields currently being received and transmitted. CTL is the basis of interrupt program work and is also the locus of the interrupt module and other local communications.

2. Communications Primitives

Communications between local area and local area relies primarily on the communications primitives PUTQ and GETQ for implementation. The function of PUTQ is to register a processing unit in the indicated queue, the function of GETQ is to access a processing unit from the indicated queue. A processing unit commonly includes the following parameters: information source, information category, data block address, and data block length. The work of each process is independent, and each processes its own work. After a task is completed, GETQ is used to get work from its own queue. When it is necessary to pass information to another process PUTQ is used to pass the processing unit to another process. This is the way these independent work processes communicate with one another and cooperate in completing larger tasks.

3. Interrupt Block INT

The interrupt block is at the lowest level in the link level. It manages input and output of character information on the four types of circuits. The hardware interrupt signal activates the interrupt program. If it is an input interrupt, depending on the indicators in the circuit characteristics table, the characters received are placed in a buffer; if it is a transmit interrupt, depending on the indicators in the circuit characteristics table, the followup characters are sent to the circuit, each time an entire information field is received or sent, a mark is made in the characteristics table in the interrupt program and information transactions of other processes and the interrupt module use the entire information field as the basic unit.

For circuits between machines, this information field is a frame; for remote terminal circuits of Changsha City [?] telephone network, the information field is a text; for circuits connecting local five-bit and seven-bit devices, the information field accepts the carriage return as the concluding character or the character string that fills the buffer. In the international number two code used by 5-bit telecommunications devices, when outputting, the interrupt program converts the ASCII character into 1-4 five-bit characters and telecommunicates them in sequence; when inputting, the interrupt program converts the 1-4 five-bit characters into the corresponding ASCII characters. After adding I through the interrupt program, the other programs no longer sense any difference between the five-bit devices and the seven-bit devices.

4. Event Analysis Process EVT

The event analysis process EVT is a timing task. It reads the circuit characteristics table and analyzes the events appearing on the circuit. If a buffer's information is transmitted and it will not be used again, the buffer is released to the free buffer pool; if a complete information field is received, then a new buffer is requested for the circuit to receive the characters. Information fields received by a local terminal are directly

transferred to the PAD process. Information text, control text, and no response beyond the time limit messages are passed to the appropriate processing unit and registered in the terminal link management processing LT queue. Frames and no response beyond the time limit messages received on circuits between machines are passed to the appropriate processing unit and registered in the intercomputer link management process LL queue.

5. Terminal Link Management Process LT

The terminal link management process LT implements a finite automaton (see Table 1). This automaton expresses the primary content of the BL protocol.

Table 1. Automaton LT

Primary station			Secondary station			Initial state	
State Event	SDA	RPS	State Event	RDA	SPS	State Event	DIS
ACK0	LT1	LT7	ETB	LT10	LT16	SEL	LT18
ACK1	LT1	LT7	ETX	LT10	LT16	DIS	LT4
NAK	LT2	LT8	ABT	LT11	LT16		
PSE	LT3	LT3	ENQ	LT12	LT16		
$\beta\beta$	LT1	LT7	$\alpha\alpha$	LT13	LT13		
BER	LT4	LT4	NBF	LT14	LT15		
TMO	LT5	LT9	YBF	LT15	LT17		
NNO	LT6	LT9	DIS	LT4	LT4		
NNA	LT6	LT9					
DIS	LT4	LT4					

The rows in the table indicate the possible states of circuit ports: sending data (SDA), receiving a pause request (RPS), receiving data (RDA), transmitting pause request (SPS), and initial link state (DIS).

The columns in the table indicate the events that can appear: acknowledge (ACK0, ACK1), negative acknowledge (NAK), pause request (PSE), requesting a reverse direction ($\beta\beta$), group interrupt (BER), beyond the time limit (TMO), over the time limit N times in a row (NNO), negative response N times in a row (NNA), disconnect circuit (DIS), information text (ETB, ETX), delete text (ABT), inquiry (ENQ), reverse direction ($\alpha\alpha$), have buffer (YBF), no buffer (NBF), and select text (SEL).

LTi in the table indicates the action to be taken when that event occurs in the corresponding state.

LT1: Release buffer occupied by information text currently transmitted, transmit next information text. Clear beyond the time limit counter and

no response counter, when information is transmitted transmit reverse direction text aa, change state to RDA.

LT2: Retransmit current information text, increment NAK count by 1.

LT3: Change state to RPS and transmit inquiry text.

LT4: Change state to DIS and transmit DIS to disconnect circuit.

LT5: Retransmit current information text, increment no response count by 1.

LT6: Inform operator that no response has appeared N times in a row or no response has appeared N times in a row.

LT7: Change state to SDA, transmit next information text.

LT8: Change state to SDA, retransmit current information text.

LT9: Reactivate timer, and transmit inquiry text.

LT10: Audit check sum, determine whether to send text to acknowledge positively or negatively.

LT11: Negative acknowledgement text is sent.

LT12: Transmit current ACK or NAK text.

LT13: Change state to SDA, transmit information text via this line's output queue.

LT14: Transmit request for pause, SPS.

LT15: No action.

LT16: Retransmit PSE text.

LT17: Change state to RDA.

LT18: Change state to RDA, transmit acknowledgement, ACK.

6. Intercomputer Link Management Process LL

The intercomputer link management process LL implements another finite automaton (see Table 2). This automaton expresses the major content of the HL protocol.

The rows in the table indicate the possible states of circuit ports: sending data (SDA), receiving a pause request (RPS), receiving data (RDA), transmitting pause request (SPS), and initial link state (INIT).

Table 2. Automaton LL

Primary station			Secondary station			Initial state	
State Event	SDA	RPS	State Event	RDA	SPS	State Event	INIT
RR	LL1	LL7	I	LL10	LL12	SABM	LL14
REJ	LL2	LL8	YBF	LL9	LL13	UA	LL15
RNR	LL3	LL9	NBF	LL11	LL9		
TMO	LL4	LL4	DIS	LL6	LL6		
NNO	LL5	LL5					
NNA	LL5	LL5					
DIS	LL6	LL6					

The columns in the table indicate the events that could appear: ready to receive (RR), reject (REJ), not ready to receive (RNR), beyond time limit (TMO), beyond the time limit N times in a row (NNO), rejection N times in a row (NNA), dismantle circuit (DIS), information frame (I), have buffer (YBF), no buffer (NBF), set up asynchronous balanced mode (SBA), and agree to set up asynchronous balanced mode (UA).

LL1 in the table indicates the action that should be taken when the event occurs under the corresponding state.

LL1: Release buffer occupied by acknowledged information frame and transmit following information frame, clear beyond-the-time-limit count and reject count.

LL2: Retransmit current I frame, increment reject count by 1.

LL3: Change primary station state to RPS.

LL4: Retransmit current information frame and increment beyond-the-time-limit count by 1.

LL5: Notify operator that there have been N times no responses in a row or N times REJ in a row.

LL6: Change circuit state to initial state INIT and transmit DIS frame.

LL7: Change primary station state to SDA and transmit next information frame.

LL8: Change primary station state to SDA and transmit current information frame.

LL9: No action.

LL10: Check whether or not frame sequence number is right and if so, pass data received to packet level, increment reception variable by 1, transmit RR frame; if frame sequence number is wrong, discard information sequence received and transmit REJ frame.

LL11: Change secondary station state to SPS.

LL12: Transmit RNR frame.

LL13: Change secondary station state to RDA.

LL14: Set primary station state to SDA, set secondary station state to RDA and transmit UA frame.

LL15: Set primary station state to SDA, set secondary station state to RDA and transmit I frame.

7. Call-Response Process AC

The call-response process is a timing task. It manages the call bell signal and carrier frequency signal of 16 telephone circuits. The state of each telephone circuit changes as illustrated in Figure 5. After it is discovered that there is a tell signal on a circuit, the data assembly of one computer is set to connect and if the carrier frequency signal is received within the specified time (say, 2 minutes), then the circuit is initialized, its circuit characteristic table is set to the initial value so that the circuit can enter the communications state; if the carrier frequency signal is not received within the specified time, or if the carrier frequency signal is not constantly received in the communications process, then the circuit is set to idle and waits for the user to come and use it.

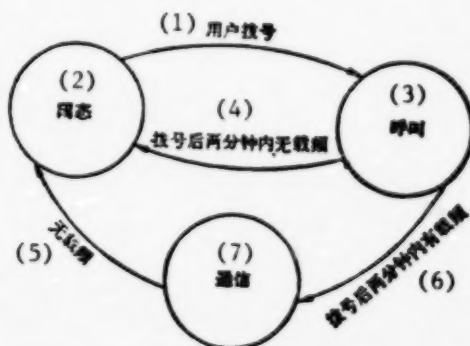


Figure 5. Diagram of Telephone Line State Change

Key:

- | | |
|--|---|
| 1. User dial number | 5. No carrier frequency |
| 2. Closed state | 6. Carrier frequency within 2 minutes of dialup |
| 3. Call | 7. Communication |
| 4. No carrier frequency within 2 minutes of dialup | |

8. Distributed Data Process DD

The function of the distributed data process is to register the data which the packet level has passed to the link level in the transmission queue of the intercomputer circuits and if a circuit is in initialized state, the DD process enables the initialization of that circuit. The aim of designing this circuit is to provide a simple and accurate interface for the packet level.

IV. Interface Between Link Level and Other Parts

The link level operations under RDOS support and the interrupt module is the RDOS user self-defined facility interrupt processing program. Other processes are RDOS user processes. Actually, the link level relies very little on RDOS. Without RDOS support one only has to write a small interrupt general program and process call program to combine with link level software to support upper level network software. This is currently implemented on the SK1 computer.

The link level hardware interface is simple, and though link level processes four types of circuits, these four circuits are connected to DJS-100 series computers asynchronous multiplexers and can receive and transmit information in character interrupt mode.

There are a total of three interface commands between the link level and the packet level:

- (1) PLDA (L-number, P-address, P-length)
- (2) LPDA (L-number, P-address, P-length)
- (3) LPER (L-number, Cause)

Here, L-number is line number, P-address is packet address, P-length is packet length, Cause is the reason for the trouble.

The packet level uses LPAD command to transmit the data between machines to the link level. The link level uses LPDA and LPER commands to pass the data received on line between machines as well as fault data received on line to the packet level.

There are only two interface commands between the link level and PAD:

- (1) LPAD (L-number, D-address, D-length)
- (2) PADL (L-number, D-address, D-length)

Where L-number the line number, D-address is the data block address, and D-length is the data block length.

The link level uses the LPAD command to pass the data received over the terminal circuit to PAD. The PAD process uses the PADL command to pass the data received over the terminal circuit to the link level.

V. Conclusion

Link level software was first developed 2 years ago when communication between machines still had to be by means of asynchronous interfaces. Its purpose was to implement synchronous duplex transparent transmissions under poor conditions and thus support software at the upper level of the network. Now, we are replacing it with synchronous interface and since we have adopted a modular structure, this change had not had a great influence on the overall link level software.

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APPLIED SCIENCES

PACKET LEVEL PROTOCOL, ITS IMPLEMENTATION

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[Text] Abstract: The application of X.25 (1977) to packet-level protocol of RDC network was investigated. Problems concerning virtual circuit, packets and their confirmation, flow control, logical channel, state diagram and state table are first discussed, then packet-level module design, including data structure, commands of interface to both transport-level and link-level, routing algorithm, etc. A flowchart of packet-level implementation is also given.

I. Introduction

Packet level, also called network level, is situated in-between the link level and the transport level. On the basis of error-free transmission provided by the link level, it provides the transport level with data transmissions between two DTE. With the development of computer networking, CCITT issued proposal X.25 which described the interface rules between a DTE (data terminal equipment, such as host computer, smart terminal, and concentrator) and DCE (data circuit terminal device) on a public data network. After the X.25 proposal was issued, many computer networks internationally adopted X.25 as the basis of their network protocols and demanded that packet level protocol of RDC nets should observe the third level of X.25 (revised in 1977) to unify international standards.

This essay describes some concrete considerations when the X.25 proposal is applied to RDC Net packet level protocols, then describes some problems to be defined and resolved in designing the packet level modules, such as the design of interface commands between the transport level module and the link level module, design of data structures, and path algorithms. Finally, the essay introduces the general frame portion in the block diagram so that the reader will have an understanding of the packet level process.

II. Considerations in Applying the X.25 to RDC Net Packet Protocols

1. General Considerations

An RDC Net is a computer network made up of a number of computers connected together, the configuration can connect any number of computers into a network, but it does not indicate which computers at the nodes (called nodes or stations) are DTE and which are DCE, but it does require that:

- (1) The same computer should be both host computer and communications node.
- (2) Allow two computers as hosts to communicate directly.

For this reason, when designing the packet level module nodes they had to have both DTE functions and DCE functions; when the nodes are in DCE position they execute the operations which X.25 defines for DCE and when they are in DTE position, they execute the operations which X.25 defines for DTE. As how to define the state of a node situated in what position, we stipulate that:

- (1) A terminal node which receives or sends data (on a virtual circuit, see section one on virtual circuits) is viewed as being in DTE position.
- (2) If a local node is connected with a node in the DTE position (on a virtual circuit), then the local node appears in DCE status.
- (3) When two nodes are both directly communicating as DTE then each node still must act as DCE in interfacing with the other party.

2. Virtual Circuits

The packet level functions lie in establishing a virtual circuit through calling between two DTE's that want to communicate and then carrying out data packet and interrupt packet transmission over the virtual circuit. To ensure that many virtual circuits can exist on a DTE/DCE interface at the same time a logic channel concept is used. The link between DTE/DCE is duplicated to make many logic channels, thus permitting each DTE to be able to link up with many DTE simultaneously and between each pair of DTE's many connections can be set up simultaneously and different virtual circuits can have the same actual path.

The link between two neighboring (i.e., having the same communications circuit) nodes on an RDC Net is reused as a multiple logic channel, one of which is used by each virtual circuit. Figure 2.1 is a diagram of three virtual circuits. The link between A/B, A/C, and B/D are reused as logic channels:

Virtual circuit (1) uses one logic channel between A/B and one logic channel between B/D, these two logic channels link up to form a virtual circuit. The terminal points A, D of this virtual circuit are in DTE position, but the node B is in DCE position.

Virtual circuit (2) uses one logic channel between A/C, A/B, B/D. These three logic channels link up to form one virtual circuit. The terminal points C and D of this virtual circuit are both in DTE position, but nodes A and B are in DCE position relative to C and D respectively.

Virtual circuit (3) uses one logic channel between B/D. This logic channel makes up a virtual circuit. At this time B and D are in DTE position but each is also in DCE position relative to the other.

In the B/D interface in Figure 2.1 there are three virtual circuit passages, two on A/B interface and one on A/C interface.

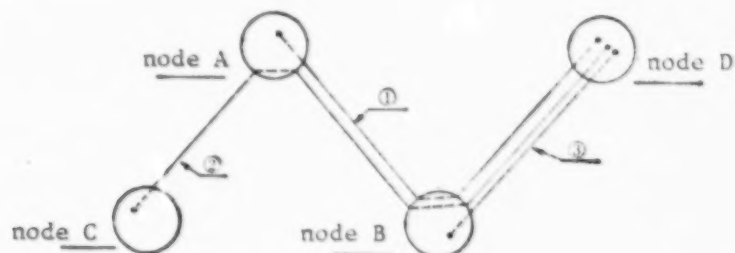


Figure 2.1. Virtual Circuits and Logic Channels of an RDC Net

3. Packet Level and Its Response Relationship

It is packets that are transmitted on logic channels. Some are used for transmitting control information and some are used for transmitting data. Same with X.25 a total of 14 packets have been designed for the RDC Net. To simplify discussion, we have listed these packets and given them abbreviated names and shorthand symbols (see Table 2.1).

Table 2.1. Packet Symbols, Abbreviations and Shorthand Symbols

Packet symbol	Abbreviation	Symbol	Functions
00001011	Call request	CAR	Requests setting up a virtual circuit with the DTE called on the designated channel.
00001111	Call confirm	CAC	Confirms request to set up a virtual circuit with the DTE called on the designated circuit.
00010011	Clear request	CLR	Requests clearing virtual circuit on the designated logic channel and giving reasons for clearing.
00010111	Clear confirm	CLC	Confirms request for clearing virtual circuit on designated logic channel.

[Table continued on following page]

<u>Packet symbol</u>	<u>Abbreviation</u>	<u>Symbol</u>	<u>Functions</u>
P(S)OP(R)0	Data packet	DATA	Transmitting data packet designated by P(S) to the other party over the designated logic channel and notifying the other party that this party is ready to receive data packet designated by P(R) over the logic channel.
00100011	Interrupt request	INR	Transmits interrupt packet over the designated logic channel and gives interrupt information.
00100111	Interrupt confirm	INC	Confirms interrupt request sent by other party on the designated channel.
P(R)00001	RR	RR	Notifies other party that this party is ready to receive data packet designated as P(R) on the designated logic channel.
R(R)00101	RNR	RNR	Notifies other party that this party cannot continue to receive further data packets on the designated logic channel.
P(R)01011	REJ	REJ	Notifies other party of request to retransmit data packet designated P(R) and subsequent data packets.
00011011	Reset request	SER	Requests that virtual circuit be reset on designated logic channel and gives reason for reset.
00011111	Reset confirm	SEC	Confirms request to reset virtual circuit on designated logic channel.
11111011	Reactivate request	STR	Used to simultaneously clear all called virtual circuits on the interface between two nodes and resets all permanent virtual circuits.
11111111	Reactivate confirm	STC	Confirm reactivate request.

Note: In the table the logic channel is the logic channel designated by the logic channel number and logic channel group number in the packet. This party refers to the terminal node which is transmitting the data packet or controlling the packet and the other party refers to the terminal node which is receiving the data packet or controlling the packet, P(S) and P(R) both take up three bits and take values from 0 to 7.

When the RDC packet level implements the above 14 packet receptions and transmissions it uses the following methods:

(1) Since setting up a virtual circuit is something which has overall significance, end-to-end confirmation mode is used for call requests. The packet level is responsible for transmitting the CAR packet by begin with calling DTE node by node to the DTE called by a certain path algorithm. On the actual path used, between each station the virtual circuit linked by the logic channel used by the CAR packet is transmitted and when the DTE called agrees to the call request, the packet level transmits the CAC packet back to the DTE called along the same virtual circuit and after this, the virtual circuit enters the duplex data transmission stage.

In the RDC Net, a virtual circuit established in the calling stage cannot be changed until the virtual circuit is cleared.

(2) Point-to-point confirmation mode is used for clearing requests because clearing is a forced command, especially when there is a rule error, the virtual circuit can no longer transmit data thus it is best to release the logic channel resources occupied by the virtual circuit as quickly as possible.

(3) End-to-end confirmation mode is used for data packet and interrupt packet. Data packet end-to-end confirmation means that only the DTE which is receiving the data packet can give the corresponding data packet receiving sequence P(R). Other stations only play a role in transmitting P(R). And interrupt packet end-to-end confirmation means that only a DTE which receives an interrupt packet can give interrupt confirmation.

(4) Point-to-point confirmation mode is used for the reset request. Generally speaking point-to-point confirmation mode can make packet level processing simple and highly efficient and it can also be unified with the clear request processing mode. However, unlike the clear request, the aim of reset is to initialize the virtual circuit and not to release logic channel resources.

(5) End-to-end confirmation mode is used for restart request.

(6) In implementing the packet level, since memory resources are limited, the packet level modules should not be too big, therefore we imposed limitations on optional user tasks and unified the window size and the maximum packet length, but we have not yet established a time limit mechanism.

4. Flow Control Structure

To keep the data packets from unlimited crowding of the packet exchange network, X.25 introduced window structure for control of the data packets on each virtual circuit.

RDC Net flow control is implemented separately at both ends of the DTE/DCE interface and since it uses uniform maximum packet length and uniform window size, RDC Net flow control can be designed as follows:

First, at the DCE node



carries out a window check on the P(S) received (i.e., the data packet received with the transmission sequence number P(S), similar situations will not be explained again), to see whether it satisfies

$$WPR \leq P(S) < WPR + WS$$

(in which WPR is the value of the P(R) most recently sent by the station, i.e., the value of the P(R) carried in the RR packet and the data packet sent to the DTE; WS is the window size, ditto below). If it is satisfied, then it transmits this data packet, otherwise it initiates reset.

Next, at the DTE node



carries out a window check on the P(S) transmitted to see if it satisfies

$$LPR \leq P(S) < LPR + WS$$

(in which LPR is the value of P(R) most recently received by this station). If it is in the window, then this data packet is sent, otherwise it is not.



A sequential check is carried out on the P(S) received to see if it satisfies

$$P(S) = IPR$$

(in which IPR is the value of the P(R) most recently sent by this station, IPR = the value of the last P(S) received + 1). If it is not satisfied, then it initiates reset. Those which satisfy the sequential check definitely satisfy the window check.



A range check is carried out on the P(R) received to see if it satisfies

$$LPR \leq P(R) \leq PS$$

(in which PS is the value of the P(S) of the data packet which this station is ready to send). If it is satisfied, the P(R) is made the lower edge of the window, otherwise, reset is initiated.

5. State Diagram of the Logic Channels

Packet reception and transmission is carried out on certain logic channels. For systematic work, X.25 provides logic channel state diagrams. When carrying out packet level rules, changes in the logic channel state are considered at the station on one side of the logic channel node.

In the light of the call set up stage, X.25 stipulates that when a call collision occurs, the DCE should let the call request through and cancel the call directive. This point is reflected in that in the implementation of RDC Net packet level in two neighboring nodes one sets a "yield" marker and the other sets an "occupied" flag in the physical link between them (see section one part four) and when a call collision occurs, the node marked "yield" will process according to the actions stipulated for DCE in X.25.

In view of the stipulations on packet response relations in section three part two, for example, that the point-to-point confirmation mode is adopted for clear requests, then P_6 state is only implied and is not repeated. Similar situations can be analogized for reset and restart. Again, in view of the fact that in packet level implementation a time limit mechanism has not yet been set up, thus we derive the practical logic channel state diagram illustrated in Figure 2.2.

Since restart rules are used in clearing all calling virtual circuits on the DTE/DCE interface and resetting all permanent virtual circuits, therefore, what r_0 and r_2 in the diagram each actually refer to is the state of the physical link between interfaces.

6. State Matrix Tables

In addition to logic channel state diagrams, X.25 also formulates for the DCE the action format which should be adopted when the DTE accepts various packets under various states. Generally speaking, this also can be used as reference for the DTE. Combining the action tables and the logic channel state diagrams and considering them one can derive a state matrix table for writing the packet level module. This form is very visual and is not hard to derive so, due to space limitations, we will not deal with it here.

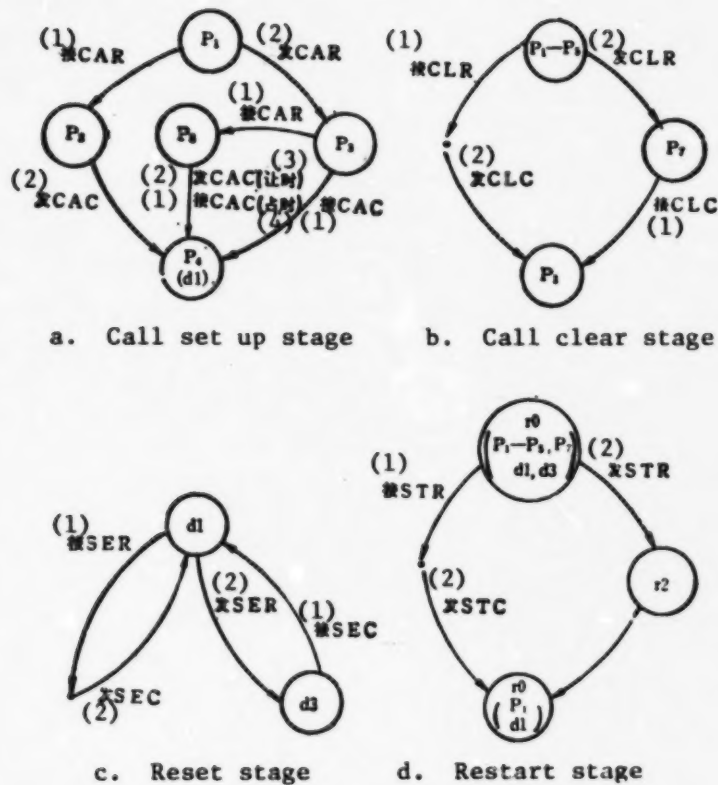


Figure 2.2. Logic Channel State Diagram

Key:

- | | |
|------------|------------------|
| 1. Receive | 3. When yield |
| 2. Send | 4. When occupied |

III. Design of Interface Commands Between Neighboring Second Level Modules

1. Interface Relations

In a node, the packet level module will interface with the transport level module TS and the link level module LL. The interface relations are illustrated in Figure 3.1.

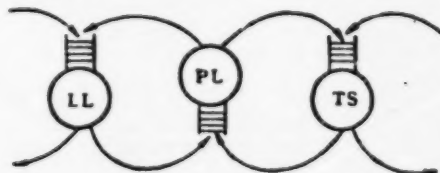


Figure 3.1. Interface Relations Between PL and TS and Between PL and LL

In an RDC Net, the communications between modules at the various levels is implemented by means of the two queue operations primitives PUT and GETS (and GET). Only one process was set up for the packet level (under present circumstances where three 100-series computers are linked together, it is a single task under RDOS control), thus PL also is used to express the packet level process. In an RDC Net, when any process needs the services of another process, through PUT it registers the processing unit in the relevant processing queue; through GETS (or GET), any one process accesses a processing unit from this processing queue and carries out the process demanded and thus serves another process. The processing unit format differs as the needs of the level differ.

The design of the interface commands is also the design of processing units. The processing unit between TS and PL is determined by what functions PL can provide and what demands TS has. The relation between PL and TS are packet level reception and transmission, therefore they are rather simple.

2. Interface Commands Between PL and TS

TS → PL:

TCAR--demands set up of a virtual circuit.

TIND--agrees to the request of a remote TS to set up virtual circuit.

TNCA--disagrees with request of a remote TS to set up virtual circuit.

TDATA--demands transmission of a data packet.

TINR--demands transmission of an interrupt packet.

TSER--demands reset of virtual circuit.

TCLR--demands clearing of virtual circuit.

PL → TS:

PCAR--relays to TS the request of a remote TS to set up virtual circuit.

PIND--reports to TS that remote TS has agreed to request to set up of a virtual circuit here.

PDATA--relays data packet to TS.

PINR--relays interrupt packet to TS.

PSER--reports to TS, virtual circuit is reset.

PCLR--reports to TS, virtual circuit is cleared.

3. Interface Commands Between PL and LL

PL → LL:

PLDA--demands LL send a packet on a designated circuit.

LL → PL:

LPDA--LL delivers a packet.

LPER--LL reports link trouble.

LPRC--actually, this is a controller command. By the controller command the analyzer program converts into the processing unit and notifies PL that the link with the problem has been repaired.

IV. Physical Link Tables and Logic Channel Tables

1. Physical Link Tables

In the RDC Net there are nodes connected by communications circuits which are called neighboring nodes. The packet level feels that there is a physical relationship between neighboring nodes. A node can have several physical links connecting it with other nodes.

To depict graphically the characteristics of physical links and the states in which they can exist, a physical link table should be set up. The table takes up three words and records:

0	1	...	4	...	6	7	...	10	...	15
P	U	0	0	0	0	r state	0	0	communications circuit number	
0	0	0	0	reused logic channel numbers						
0	logic channel table address of zero-th logic channel									

in which:

(1) P bit is "yield" and "occupied" marker bit if

$$P = \begin{cases} 0, & \text{for yield: it indicates that the logical channel should} \\ & \text{be divided from small to large, and that when the call} \\ & \text{collision occurred, the station was processing in DCE} \\ & \text{position.} \\ 1, & \text{for occupied: situation just the opposite of the above.} \end{cases}$$

(2) U bit is the trouble bit if

$$U = \begin{cases} 1, & \text{link trouble, LL reports final position of link trouble,} \\ & \text{controller commands indicate that it is repaired or to} \\ & \text{clear after other party issues a STR packet.} \\ 0, & \text{link is normal.} \end{cases}$$

(3) r state is restart stage state and occupies bits 6 and 7.

$$6, 7 = \begin{cases} 00, & \text{is r0 state.} \\ 10, & \text{is r2 state.} \end{cases}$$

(4) Communications circuit number is the QTY circuit number (one of 0-64₁₀ lines) occupied on this node for the physical link.

(5) Reused logic channel number refers to how many logic channels are reused on this physical link. These logic channels are numbered sequentially beginning with 0.

(6) Logic channel table address of the zero-th logic channel, since logic channels are numbered sequentially beginning with 0, and the logic channel table is continuously arranged, the logic channel table address can be found on the basis of the logic channel table address and the logic channel number based on the zero-th logic channel.

2. Logic Channel Table

This table records necessary information about the logic channel and takes up 6 words:

0	1	...	4	...	7	8	...	10	11	...	13	...	15
PVC					INT	FL			d state			p state	
CHAIN													
(PHLI)				(LGID)									
	WS					WPR							
	PS					LPR							
	IPR					NUMBER							
HEAD													

in which:

(1) PVC bit is the marker bit of the permanent virtual circuit.

$PVC = \begin{cases} 0, & \text{this logic channel is not a permanent virtual circuit.} \\ 1, & \text{this logic channel is a permanent virtual circuit.} \end{cases}$

(2) INT bit is the marker bit for whether or not an INR packet can be received again, only with an FL = 1 logic channel can the INT bit be filled.

$INT = \begin{cases} 0, & \text{indicates that it can receive (or send) INR packets.} \\ 1, & \text{indicates that it cannot receive INR packets.} \end{cases}$

(3) FL is flow control marker and indicates whether or not this station is in DCE position in flow control processing.

$FL = \begin{cases} 0, & \text{indicates that this station is not in DCE position.} \\ 1, & \text{indicates that this station is in DCE position.} \end{cases}$

(4) p state and d state occupy 3rd and 2nd bits respectively and are used to record the p state and d state of this logic channel. For example, if the value of the 3rd bit which is occupied by the p state is 1, it means that it is in p₁ state and the other states are similarly expressed.

(5) CHAIN is the chain syllable. The first four bits are called the PHLI syllable and the last 12 are called the LGID syllable. They are used to record which physical link (indicated by the first four bits) and which logic channel (indicated by the last 12 bits) this logic channel is chained with.

If the PHLI syllable = 0000, then this logic channel is connected with TS and the value of LGID at this time is the INDEX number used by TS to call this virtual circuit.

(6) WS syllable records the window measurements. Since P(S) and P(R) can be modulus 128, 7 bits are reserved, but currently modulus is 8, so it takes up only 3 bits. It is the same with WPR, PS, LPR, and IPR described below. For ways of using each syllable, see section 4 in part two.

(7) WPR syllable is used by FL = 1 logic channel to record whether the window and its value is equal to the P(R) value in the confirmation packet used (i.e., the data packet and RR packet).

(8) PS syllable records the P(S) value of the DATA packet issued when the station is a terminal node.

(9) LPR syllable records the P(R) value in the most recent confirmation packet received from the other terminal when the node is a terminal node.

(10) IPR syllable records the P(S) value of the DATA packet expected from the other terminal when the station is a terminal node.

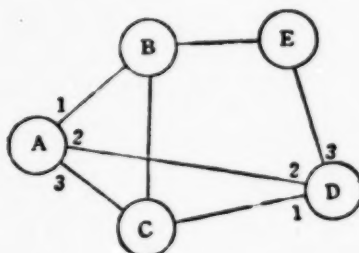
(11) NUMBER syllable refers to the data packet unit number waiting to be sent because of limitations in the window of this terminal.

(12) HEAD syllable records the head of the address chain of the data packet waiting to be sent.

Please note that both the physical link table and the logic channel table refer to the table recorded for the station at one end of that physical link and that logic channel, and of course, the node on the other side also has corresponding tables. They record information from the angle of each station and cannot have uniform records which override the station.

V. Path Algorithm

RDC Net currently uses a (selected) fixed path algorithm, i.e., before the fact, a path table is arranged for each node. Figure 5.1 gives the path table for node A when an RDC Net has 5 nodes. Of course, as the situation changes, the path tables also can be revised.



Node A path table

Target node	Second choice	First choice
A	0	0
B	3	1
C	1	3
D	3	2
E	2	1

Node D path table

Target node	Second choice	First choice
A	1	2
B	2	3
C	2	1
D	0	0
E	1	3

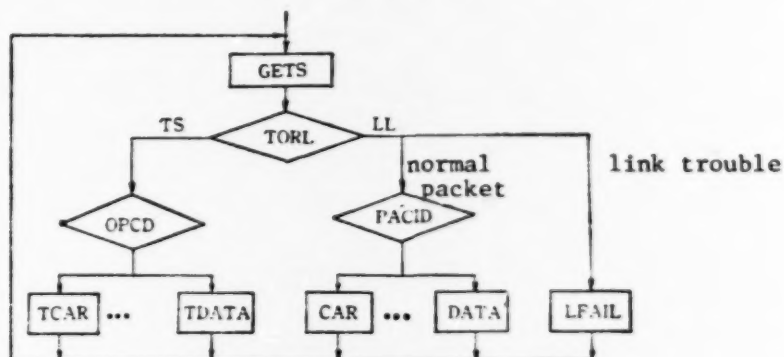
Figure 5.1. RDC Net Path Algorithm

For example, there is a call request packet at node A (only call request packets carry out path selection in an RDC Net) to be sent to target node E. It first of all selects link 1 to transmit the packet, and if problems occur on link 1 or there is no logic channel ready, then it transmits the packet on its second choice, link 2. When it transmits along the first choice, node B takes the packet and then transfers the call packet over node B path table; when node D receives the packet by the second choice transmission, D node first considers transmitting the packet on the logic channel on link 3 which is ready, then considers transmitting the packet on the logic channel on link 1 which is ready.

The nodes on the RDC Net now use an all-network unified numbering which will be made the network address of the node. Thus we can find the path information by the offset variable in numbering. Note that the link number of the nodes is not exactly 0, the 0 in the path tables indicates that the station is a target station.

VI. Introduction to the General Framework

The packet level process PL operates under the control of the general framework (see figure below), since the general framework constantly draws processing units from the processing unit queue for analysis and processing, each time a processing unit is drawn, there is a need to determine whether the processing unit is from TS or LL before it is processed.



in which the meaning of each frame is as follows:

- (1) GETS: PL process draws a processing unit through GETS sequence.
- (2) TORL: Determines whether the processing unit comes from TS or LL and if it is from LL then it must be determined whether it is a normal packet which has been passed or a report of link trouble and then process it in PACID or LFAIL frames.
- (3) OPCD: When a processing unit is passed from TS, the processing unit should be analyzed to determine which kind of the TS → PL it is and transfer it to the sub-frame. Since there are seven different processing units, there are seven sub-frames which use names similar to the processing units: TCAR, TIND, TNCA, TDATA, TINR, TSER, TCLR. TCAR processes requests to set up virtual circuits; TDATA processes requests to transmit data packets; ...
- (4) PACID: Consists of public information, and analyzes which type of packet is passed from LL, i.e., transfer it to the sub-frame depending on the packet marker. Since there are 14 packets, there are 14 sub-frames, which use abbreviated names similar to those of packets: CAR, CAC, CLR, CLC, DATA, INR, INC, RR, RNR, REJ, SER, SEC, STR, STC. CAR processes call request packets received; DATA processes data packets received; ...

(5) FAIL: Carries out appropriate work when there is link trouble.

Thus, the packet level modules are made up of the general framework and 21 sub-frames. After the processing of each frame and the LFAIL frame is completed they return to the general frame GETS, and continue to draw processing units and analyze processing until finished.

VII. Conclusion

The RDC test net has already gone into operation and has satisfied the demands of users transmitting data over the network. The packet level modules we have designed provide some experience for future implementations on packet level protocols. Currently, the packet level modules have only basic functions and need to be strengthened and improved for optional user tasks, time limit mechanisms, and path algorithms as the RDC Net moves into a new stage. In February 1980 CCITT issued revised X.25 proposals which increased such important service functions as digital data reporting and the RDC Net packet level also should give this full consideration.

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LIFE SCIENCES

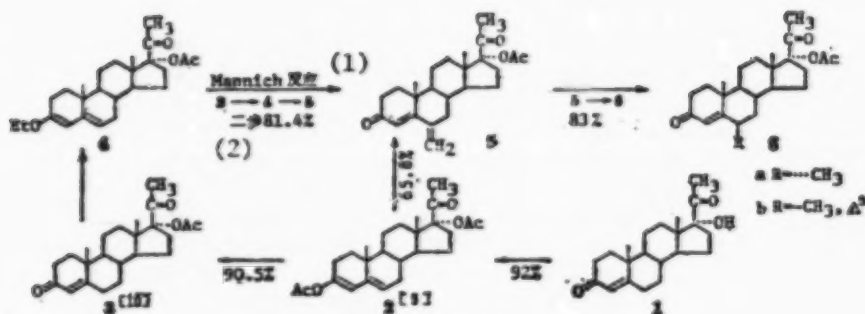
NEW SYNTHETIC ROUTE FOR MEGESTROL ACETATE REPORTED

Shanghai YOUJI HUAXUE [ORGANIC CHEMISTRY] in Chinese No 6, Dec 83 pp 451-453

[Article by Ni Yuan [0242 0337], Yu Xindi [0151 2450 1229] and Cai Zuhui [5591 4436 1926] of the Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, and Zhang Shuiquan [1728 3055 3123] of the Shanghai Pharmaceutical Plant No 12: "A Simple Synthetic Route for Δ^6 -6-Methyl-17a-acetoxy-progesterone (Megestrol Acetate)"; Received 29 November]

[Text] Megestrol acetate (Δ^6 -6-methyl-17a-acetoxy-progesterone, 6b) is an effective steroid contraceptive.^[1,2]

The steroid is generally introduced in the following three ways: By applying the Mannich reaction to 5,6-epoxide produced through peracid reaction;^[3,4] by producing dibromomethylene via carbon tetrabromide-pyridine reaction and then hydrogenizing and isomerizing the product;^[5] or by producing C₆-methylene (5) through the Vilsmeier method and isomerizing this product with palladiumcarbon.^[6] The latter method is currently employed in China. Recently, Annen et al. have reported a simplified method of producing the C₆-methylene steroid (5).^[7] This method involves a single step in which 17a-acetoxy-progesterone (3) is treated with diethylmethane (or dimethoxymethane) in a phosphorus oxychloride reaction. Our laboratory employed $\Delta^{3,5}$ -3,17a-diacetoxy-progesterone (2) and the reaction conditions reported by Annen et al. to produce C₆-methylene (5) in a yield of 65.8 percent. Since $\Delta^{3,5}$ -3,17a-diacetoxy-progesterone (2) is a precursor of 17a-acetoxy-progesterone (3), the synthetic procedure can be shortened. We also employed enol ether (4) from 17a-acetoxy-progesterone (3) to obtain C₆-methylene (5) via the Mannich reaction and then isomerized this product with palladium/calcium carbonate to obtain our desired product, megestrol acetate (6b). As the diagram indicates, route A (1→2→5→6b) produces megestrol acetate (6b) in a total yield of 50 percent, which is equal to the highest yield reported in the literature, but the process is shortened. Route B (1→2→3→4→5→6b) produces a total yield of 56 percent, which is better than the highest yield reported in the literature.^[6]



- (3) 路线 A (1→2→5→6a) 50.2%
路线 B (1→2→3→4→5→6a) 56%

Key: 1. Reaction 2. Two steps 3. Route

Generally, methyl progesterone (6a) and megestrol acetate (6b) are both prepared by isomerizing C_6 -methylene (5) with a palladium/hydrocarbon in the presence of cyclohexene. We achieved a high yield of megestrol acetate (6b) by isomerizing C_6 -methylene (5) with palladium/calcium carbonate in the presence of sodium acetate and one percent cyclohexene. Even though the reaction time was prolonged approximately 16-fold, the methyl progesterone 240 nm absorption peak did not appear in the reactants under ultraviolet spectrometry.

Experimental

Although demonstrated, the melting point was not corrected. We employed the WZZ-1 to compare polarization, the Shimadru UV-200 and the UV-730 for ultraviolet spectrometry, the UR-10 for infrared spectrometry, the Varian XL-200 and the EM-360 to determine NMR and the JMS-01V for mass spectrography.

6-Methylene-17a-acetoxypregesterone (5) [6a]

(A) In a 250 ml ground glass flask, we added in succession 1 g of $\Delta^{3,5-3,17a}$ -diacetoxypregesterone (2), 1 g sodium acetate, 30 ml chloroform, 30 ml diethylmethane and 3.8 ml phosphorus oxychloride and reacted and treated this mixture according to the conditions reported in the literature. [76] We employed dichloromethane-methanol to recrystallize the residue, obtaining 400 mg of C_6 -methylene (5), m.p. 227-229°C, and recrystallized the solution again, m.p. 234-236°C, obtaining an additional 210 mg of C_6 -methylene (5) for a total yield of 65.8 percent, $[\alpha]_D^{20} + 197^\circ$ (CHCl₃, C_6 0.85).

UV $\lambda_{max}^{E1(OH)}$: 260nm (ϵ 16800),

IR ν_{max}^{total} : 3075 (C_6 -CH₂) 1735, 1260 (C_{17a} -OCOCH₃), 1610, 1675 (Δ^4 -3-keytone), 1710 (C_{13} -keytone) cm^{-1} .

¹H NMR δ value (CHCl₃, 60 MHz, TMS): 0.65 (s, 3H, C_{18} -CH₃), 1.09 (s, 3H, C_{19} -CH₃), 2.06 (s, 3H, C_{17a} -OCOCH₃), 2.12 (s, 3H, C_{21} -CH₃), 5.0, 5.10 (2m, $W_{1/2}$ = 4Hz, 2H, C_6 -CH₂), 5.98 (s, 1H, C_4 -H).

MS m/z : 384 (M^+).

(B) In a 100 ml round-bottom flask, we added 5 g of 17 α -diacetoxy-progesterone (3), 50 ml absolute benzene, 7 ml absolute alcohol, 3.9 ml triethylorthoformate and 21 mg paratoluene sulfonic acid and heated, stirred and refluxed this mixture in an oil bath for 70 minutes. When the solution cooled to room temperature, we added 1 ml pyridine, and after the solution concentrated under reduced pressure, we added 50 ml ethyl alcohol and 25 ml chloroform, which we dissolved by heating the mixture. When the latter cooled to 10°C, we added 1.9 ml methylaniline, 7.5 ml of 37 percent formaldehyde and 120 mg paratoluene sulfonic acid; stirred the mixture for 20 minutes; and then reacted the ingredients at 60°C for 1 hour. Next, we added 2 ml pyridine, and after the solution had concentrated under reduced pressure, we added 20 ml methanol and shook the mixture. When the latter cooled to 5°C, we added 20 ml concentrated hydrochloride and stirred the mixture for another 2.5 hours. Then we removed solids through filtration, neutralized the filter cake by washing it in water and dried the product, obtaining 4.88 g of a yellow powder, which we recrystallized by adding ethyl acetate, obtaining 4.2 g of a darkish-white crystal, m.p. 232-235°C, in a yield of 81.4 percent. The $[\alpha]_D$, IR, NMR, MS produced were exactly the same as the C₆-methylene (5) obtained in method A.

Δ^6 -6-Methyl-acetone-progesterone (6b, megestrol acetate, megestrol acetate ester acetate)

In a 500 ml round-bottomed flask, we added 10g C₆-methylene (5), 200 ml absolute alcohol, 4 g anhydrous sodium acetate, 7 g palladium/calcium carbonate and 1 percent cyclohexene and heated and stirred this mixture for 1 hour. We employed ultraviolet spectrometry, and when the characteristic absorption peak of only 288 nm for megestrol acetate (6b) was attained, we terminated the reaction. While the solution was still hot, we filtered it, concentrated the filtrate under reduced pressure, dried this product, added cold water, crushed the resulting solids, filtered the solution again and neutralized it. When the mixture dried, 9.7 g of a yellow powder was obtained, which we recrystallized with dichloromethane ethylate, obtaining 8.3 g of a white crystal in a yield of 83 percent, m.p. 217-219°C, $[\alpha]_D^{25} + 11.5^\circ(\text{CHCl}_3)$.

UV $\lambda_{\text{max}}^{\text{EtOH}}$: 287 nm(ϵ 25400).

IR $\nu_{\text{max}}^{\text{major}}$: 1730, 1250(C_{17 α} -OCOCH₃), 1700(C₂₀-ketone), 1580, 1620, 1660(Δ^4 -3-ketone) cm⁻¹.

¹H NMR δ value(CHCl₃, 60MHz, TMS): 0.70 (s, 3H, C₁₈-CH₃), 1.10(s, 3H, C₁₉-CH₃), 1.89 (s, 3H, C₄-CH₃), 2.00(s, 3H, C_{17 α} -OCOCH₃), 2.06(s, 3H, C₂₁-CH₃), 5.77(s, 1H, C₄-H), 5.9 (s, 1H, C₆-H).

MS m/z , 384(M⁺).

REFERENCES

- [1] a. Nagata Wataru and Itazaki Hiroshi, in "Shin Iyakuhin no Goseiho" [Methods for Synthesis of New Drugs], Vol 2, ed. Tsuda Kyosuke and Nogami Hisashi, Tokyo, Chijin Shokan, 1972, p 525.
b. V. Petrow, CHEMICAL TECHNOLOGY, No 7, 1977, p 563.
- [2] a. Shanghai Institute of Organic Chemistry, Department 1, Group 101, YOUJI HUAXUE [ORGANIC CHEMISTRY], 1981, p 149.
b. Yang Yiqian [2799 0110 6197] et al., SHENGZHI YU BIYUN [REPRODUCTION and CONTRACEPTION], Vol 2, No 4, 1982, p 23.
- [3] H. J. Ringold et al., JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, No 81, 1959, p 3712.
- [4] J. C. Babcock et al., Ibid., No 80, 1958, p 2904.
- [5] S. Liisberg et al., TETRAHEDRON, No 9, 1960, p 149.
- [6] a. D. Burn et al., Ibid., No 20, 1964, p 579.
b. D. Burn et al., Ibid., No 21, 1965, p 1619.
- [7] a. K. Annen et al., Ger. offen. DE 3,004,508 (1981); CHEMICAL ABSTRACTS, No 96, 1982, p 6951.
b. Idem., SYNTHESIS, 1982, p 34.
- [8] a. Van Rheen and H. Verlan, Ger. Offen. DE 2,055,895 (1971); U.S. 3,642,840 (1972); CHEMICAL ABSTRACTS, No 75, 1975, p 49443j.
b. Cai Zuhui et al., YAOXUE XUEBAO [ACTA PHARMACEUTICAL SINICA], No 17, 1982, p 233.
- [9] N. R. Pemmaraju and B. E. Edwards, U.S. 3,321,495 (1967); CHEMICAL ABSTRACTS, No 67, 1967, p 117103k.
- [10] M. Windholz, "Merck Index," 9th ed., New Jersey, Merck Co, 1976, p 4756.

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18 JULY 1986

China Report

SCIENCE AND TECHNOLOGY

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18 JULY 1986

CHINA REPORT

SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

1985 TECHNOLOGY MARKET STATISTICS REPORTED

Tianjin JISHU SHICHANG BAO in Chinese 11 Mar 86 p 1

[Text] According to statistics and figures announced recently by the State Science and Technology Commission 1985 was a year of abrupt development for China's technology markets. Statistics from 36 provinces, autonomous regions, directly administered municipalities, and individual cities, and from 34 ministries affiliated with the State Council show that there were 34,740 technology negotiation projects (among which were 17,600 contracts), negotiated funds totalled 10,867,520,000 yuan (contracted amounts among which were 4,730,290,000 yuan), 17,103 projects were locally affiliated for 49.23 percent of negotiation projects, and negotiated amounts were 398.42245 billion yuan, which was 36.66 percent of the total; 17,637 projects were affiliated with departments, which was 50.77 percent, and negotiated amounts were worth 6,883,290,200 yuan, which was 63.34 percent. Because last year the banks were retrenching and bank loans were difficult, by the end of last year, the total number of projects implemented by local areas and departments were 9,932 (8,128 of which were contracted), which was 28.60 percent of the total negotiated. Total value of deals transacted was 2,303,951,600 yuan (among which 2,018,954,300 yuan was contracted), which was 21.20 percent of the negotiated amounts (the proportion of contracts implemented was 42.68 percent). Looking at things from our current viewpoint, business activities in the technology markets are largely undertaken between science research organizations on the one hand and small to medium enterprises and township and town enterprises on the other. The value of transactions in these areas was more than 60 percent of the value of transactions at the first national technology achievements trade fair.

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NATIONAL DEVELOPMENTS

S&T AWARDS FROM 6TH 5-YEAR PLAN REPORTED

Tianjin JISHU SHICHANG BAO in Chinese 11 Mar 86 p 1

[Text] During the period of the "Sixth 5-Year Plan," our Party and government adopted many major measures for protecting, encouraging, and disseminating scientific and technical achievements, which were quite effective. According to the most recent statistics from 40 departments from 29 provinces, autonomous regions, directly administered municipalities, and the State Council, there were 34,045 major achievements recommended to the state during the period of the "Sixth 5-Year Plan"; 44,540 scientific and technical achievements were awarded national and provincial level prizes.

The situation regarding awards for scientific and technical achievements, based on statistics of 18 departments from 23 provinces, cities, autonomous regions, and the State Council, was that among the 98,245 scientific and technical achievements, 91,930 were technical achievements, 93.6 percent of the total; there were 6,315 theoretical achievements, for 6.4 percent. Among these scientific and technical achievements, 5,247 were of an international standard, 3,336 were part of national planning, 31,450 were completed by independent science research units, and 35,220 were of a general level. With the full scale development of the restructuring of the science and technology system, science and technology in this country are catering to economic construction. During the period of the "Sixth 5-Year Plan," 2,834 won national awards, which included 937 winning national prizes for invention, 125 won national awards for the natural sciences, and 1,772 were judged for the first time for national science and technology prizes. Economic results after application of these prize winning inventions have, in all, increased income or savings of about 30 billion yuan, 32 projects among which accounted for more than 100 million yuan for a total value of 26.612 billion yuan. According to preliminary statistics, projects completed during the "Sixth 5-Year Plan" had total gains in income or savings of about 76.5 billion yuan. Thirty-two first prize or higher projects among which totalled 24.6 billion yuan.

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NATIONAL DEVELOPMENTS

LU JIAXI EXPLAINS 7TH 5-YEAR PLAN S&T GOALS

Beijing RENMIN RIBAO in Chinese 7 Apr 86 p 1

[Report by Chen Yun [7115 5366]: "Conditions Exist in This Country Such That We Can Make Great Accomplishments in Fields of High Technology"]

[Text] Lu Jiaxi [4151 0857 6932], National People's Political Consultative Conference (CPPCC) committee member and president of the Chinese Academy of Sciences, has said that the mission proposed for China's science and technology circles by the "Seventh 5-Year Plan" draft plan is a formidable one, but as long as we strive to work together and to do our work well, then it is something we can realize.

According to requirements of the draft plan, during the period of the "Seventh 5-Year Plan," we will strive for great achievements in research and development in the fields of new technologies and high technologies. At the Fourth session of the Sixth National CPPCC when Lu Jiaxi spoke to reporters about this mission, he said that the key to China developing high technology is in organizing and concentrating our strength in solving problems, in breaking up the old system of departmentalization and control by professions, in implementing lateral relations, and in enhancing coordination. He said that although when comparing our conditions with those of advanced countries there are significant gaps, these are in regard to the overall levels of science and technology, and actually in many respects current standards approach or attain advanced international standards. He said that we can neither be blindly arrogant in scientific and technical areas, nor should we belittle ourselves.

Committee member Lu Jiaxi went on to analyze the advantageous situation in China for developing science and technology. He said that in terms of personnel, there are several older scientists who are world recognized authorities; the abilities and enthusiasm of large numbers of young and middle aged scientists and technicians are not less than those of the same generation in similar professions throughout the world, but through what has been accumulated since the founding of the nation, and especially advances in recent years, we now have a great deal of advanced equipment; and although financially we are currently rather strapped, the state has determined that during the "Seventh 5-Year Plan" we will increase funding in these areas. With these people, finances, and materials, although we will not be entirely

well off, with great effort, we can do many things in the fields of science and technology.

Lu Jiaxi said that our nation has had some successes in developing high technology. During the 1950's, the nation determined to unify and coordinate its strength, and in the 1960's we then exploded the atomic and hydrogen bombs, and our satellites were sent up. These are examples that serve well to explain problems.

Regarding the principles of new technology research, committee member Lu Jiaxi stressed that first of all we must follow in the footsteps of advanced world technologies, and then we must strengthen basic research and innovative science and technology, as well as keep core science research contingents together. He said that our strength in science research has always been departmentalized and dispersed, with personnel often leaving. The state has now noticed these problems, and is in the process of solving them in terms of policies, which will give us the conditions under which to accomplish the mission assigned by the "Seventh 5-Year Plan" to develop new technologies and high technologies.

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CSO: 4008/2095

NATIONAL DEVELOPMENTS

REGULATIONS ON ALLOCATION OF S&T PROFITS REPORTED

Tianjin JISHU SHICHANG BAO in Chinese 11 Mar 86 p 1

[Text] Recently, on the basis of former provisions and also on actual conditions, the Shanghai Municipality Tax Bureau and the Bureau of Finance has made new provisions regarding allocation methods for income from the "Four Technologies" (transfer of the rights to technologies, technical service, technical consulting, and technical training), the substance of which is as follows:

First, beginning 1 January 1986, there will be a 3 percent operations tax figured against the totals for scientific and technical achievements from publicly owned enterprise units in Shanghai and for the gross income from sales of technology, technical service, technical consulting, and technical training. Regarding net profit after costs, where annual totals are less than 300,000 yuan (including 300,000), tax is deferred, the total sum to be retained by the enterprise; for portions that exceed 300,000 yuan, enterprises will pay the tax as regulated. For sales to Yunnan, Ningxia, Xizang, and Xinjiang, which the state has assigned for support to Shanghai, the entire amount of annual income below 400,000 yuan (including 400,000) may be retained by the enterprise, the tax to be paid by the enterprise on the portion that exceeds 400,000 yuan.

Second, the principles for disposition of net income retained by enterprises are:

1. where annual totals are 10 percent or less of the enterprise reserve funds, usage will be proportioned as follows: 30 percent for production development funds, 20 percent for staff and worker benefit funds, and 50 percent for staff and worker awards and bonuses.
2. where annual totals are more than 10 percent of the enterprise reserve funds but less than 20 percent, that portion exceeding 10 percent will be proportioned as follows: 35 percent for production development funds, 20 percent for staff and worker benefit funds, and 45 percent for staff and worker awards and bonuses.
3. where annual totals are more than 20 percent of the enterprise reserve funds, that portion in excess of 20 percent will be proportioned as follows: 50 percent for production development funds, 20 percent for staff and worker benefit funds, and 30 percent for staff and worker awards and bonuses.

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CSO: 4008/2099

NATIONAL DEVELOPMENTS

STATE S&T COMMISSION MEMBER DISCUSSES PERSONNEL PROBLEMS

Beijing RENMIN RIBAO in Chinese 10 April 86 p 5

[Article by Guo Shuyan [6753 2885 6056], vice minister of the State Science and Technology Commission: "Three Problems in the Management of Scientific and Technical Personnel"]

[Text] Problems Regarding Implementation of the Hiring System

Realizing a hiring system for intellectual laborers is quite a common thing throughout the world, but in China we have in the past maintained a unified allocation by organization. Such a system cannot meet the needs of scientific and technical development today. We should begin to implement a hiring system in areas where intellectuals are more concentrated. In April of last year the experiences of 60 units in implementing a hiring system were shared in Shanghai by the State Science and Technology Commission. The results of the implementation showed that: 1. this aided the selection of the worthy and employment of the capable and also avoided occurrences of the types of problems where particular units attacked intellectuals and harmed them, and it was beneficial as well in making the most of intellectuals and for the maturing of talent. 2. There is a certain autonomy for units and individuals in seeking personnel, in responding to such searches, and in leaving positions, which has broken up "unit ownership" and has been of use to the transformation of negative factors. 3. It has promoted the rational movement of personnel. It primarily invigorated units internally, and at the same time accelerated the rational movement of personnel between regions, departments, and professions.

At present, the main problem in realizing the hiring system has been what to do after quitting a job? In China, we have not yet perfected our social insurance and labor insurance systems, and if the contradictions are extended into society, that will not be of advantage to the security and unity of society. Even though the state has planned to explore the possibilities of social insurance during the period of the "Seventh 5-Year Plan," units must still actively help those who want to quit arrange for appropriate work, or allow for further study to create the conditions in which to find employment. But for those people who do not work responsibly, who have not responded to employment opportunities, but who do not accept unit arrangements, then organizational measures must be adopted and their wages must be reduced.

There Should Be Rational Movement of Personnel

Leading comrades of the Central Committee have pointed out: "Advocating personnel movements is a correct direction." In 1983 the State Council drew up a document encouraging the rational movement of personnel. However, the situation for the rational movement of personnel has not been truly opened up. Personnel must be moved rationally, but this is not a free movement. The cities cannot go to the countryside to find talent, and at the same time, large enterprises cannot look for talent in small enterprises, nor can inland areas go to the borders. We want to change the way in which we are employed for life, which will allow personnel to move rationally. To stabilize scientific and technical contingents in frontier and hardship areas, from now on we will progressively implement the method of fixed working periods and dynamically seek the overall stabilization of scientific and technical contingents. For example, in Xizang we are using a policy of 8-year work periods where after expiration the worker can return to his original job. In the future, we plan to work out particular working periods and preferential policies for more than 600 counties and banners at the frontiers and in hardship areas. In movements of personnel, we are opposed to departures without resignation, which is behavior that is unorganized and without discipline. Within the same city or region, it should be encouraged that units with accumulations of personnel adopt various means by which to allocate excess strength to units deficient in personnel. As it has been determined by Shenyang, where a group of technical personnel have been selected from some large units in that area to take on the jobs of factory directors or senior engineers at local enterprises, their wages being paid by the employing unit with the former unit retaining their authorized strength. This method has allowed a group of small to medium enterprises a chance at better circumstances, and as a result, a large portion of the scientists and technicians sent to the local enterprises have elected to stay in order to change conditions at the enterprises and to continue their efforts. The great majority of them have become key members of these enterprises.

Scientists and Technicians May Hold Concurrent Jobs

Why should we encourage scientists and technicians to hold concurrent jobs? Primarily, this is to better train personnel and to make better use of them. From an overall point of view, there are benefits to mathematics, science research, and to economic development, and there are advantages as well for intensifying relations between science and technology and production, for opening channels of information, and for developing individual strengths.

What is currently most sensitive is the problem of holding a second job in one's sparetime. Scientists and technicians use their spare time to engage in development and in technical service and they retain such income as it is earned. This was proposed last year by the State Council upon studying the problem of compensated transfers of technology. Under conditions that guarantee finishing work at the primary job, that scientists and technicians should appropriately engage in concurrent labor during their spare time is a good thing that can benefit the state and benefit the people, and we ought to support it. The policy limits ensure the completion of work at the primary

job and that there is no violation of the technical and economic rights of the primary unit. If we can achieve these two conditions, then leadership at all levels ought to make this possible, and consequently should change the situation of the past in which people were unwilling to be open about sparetime jobs. Naturally, what we primarily advocated regarding this question of concurrent employment was organized, guided concurrent employment. Spare time employment should first of all be reported to the leadership. There is at present an unreasonable phenomenon, namely that where there is little labor in sparetime, the benefits from it are very great; where primary work is quite arduous, the benefits are limited. This situation is not conducive to motivating staff and workers in earnest execution of their jobs. Therefore, we should study and formulate necessary restricting measures to appropriately limit the income from sparetime work. As reform of the wage system and income tax proceeds, this problem will be gradually resolved.

To take good care of the reform management of the entire science and technology contingent, to create a policy environment that can allow each scientist and technician to fully develop his own abilities and to make more contributions to society, these are both the points of departure and starting points for our reform of the personnel management system.

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NATIONAL DEVELOPMENTS

DU RUNSHENG DISCUSSES ROLE OF S&T IN RURAL POLICY

Beijing RENMIN RIBAO in Chinese 11 Apr 86 p 5

[Article by Du Runsheng [2629 3387 3932] derived from a speech given to the National and Local Science and Technology Work Experience Exchange Conference held jointly by the State Science and Technology Commission and the China Science and Technology Association; originally published in ZHONGGUO KEJI BAO: "Rely Upon Science and Technology to Strengthen the Economic Position of Agriculture"]

[Text] This year's Document No 1 from the Central Committee emphasized that we will pay close attention to the technical transformation of the countryside and rely upon science and technology to increase rural output and farmer's income. Why go so far to emphasize this direction? Because economic development of the countryside from now on will be more and more restricted by relative shortages in resources. Absolute quantities of natural resources in this country stand among the highest in the world. But our population is too great and our per capita share of those resources is far lower than the world average. One billion want to eat and wear clothes, 800 million farmers want to raise their standard of living, so this small per capita share of natural resources is obviously quite deficient.

Naturally, this idea of "quite deficient" has no absolute standard of measurement. With improvements in the ways resources are used, that deficiency can be supplemented, even to the extent that the deficiency becomes an abundance. By progressively strengthening the financial support of agriculture and by relying on scientific and technical advances to improve the utilization rate of resources in rural production, the difficulties of relative insufficiencies in natural resources can be overcome, and new prospects can be envisioned. Many nations that have already modernized their agriculture have taken these steps, so we cannot only do so ourselves, but can do so well. The key will be in earnestly recognizing the function of scientific and technical advances in accelerating rural economic development. The goal of the reforms we are currently undertaking is to bring new vitality to the economic system, but if we lack the material conditions and there are no scientific and technical advances, we will not be able to maintain acceleration of economic development for any length of time just by relying on this vitality. Reform of the economic system must go on and the propelling role of science and technology for rural economic development should be enhanced, which is the primary spirit of this year's Document No 1.

Adapting to Commercial Production Requires Dissemination of Scientific and Technical Achievements

From the point of view of the history of world economic development, and particularly of regions, advanced science and technology will always bring great benefits to economically developed regions, only after which can they be shifted to backward regions. As far as industrial categories are concerned, the benefits to industrial departments greatly exceed those to agricultural departments. Agriculture was born several thousand years ago, and there was rural civilization before that of cities. Industry only began to propel the development of urban civilization some 300 years ago, and there is a great gap between the two.

The progress of history has shown that the popularization of advanced technology is closely related to development of a commercial economy. Science is transformed into technology, and technology is transformed into production forces, these are shifted from developed regions to undeveloped regions, from developed sectors to undeveloped sectors, and are progressively advanced with the development of a commercial economy. In high-gain sectors and enterprises with large accumulations there are greater possibilities for the use of advanced technology, while on the contrary sectors and enterprises with few gains or accumulations have greater difficulties using advanced technology. And then, because they cannot use the advanced technology, profits will be reduced, accumulations will decrease, and this will lead to a vicious cycle. The backwardness of rural science and technology reflects just this sort of situation.

Benefits to advanced regions are great, as are those to advanced sectors. This is a fact that cannot be changed by good intentions. However, should it be that backwardness should always be backwardness, or that the advanced should always be the advanced, forever fixed and unchanging? That is not true, either. Science and technology will always shift from advanced regions toward backward ones, which is a requirement of commercial economic development. When beneficial relations change, science and technology will always seek out new regions with vitality in which to develop, and formerly backward regions just happen to give them this opportunity. The United States took over the foremost position in science and technology from certain European countries, and after the Second World War, the economy of Japan flourished. Some countries and regions that have developed to a middle grade of development or that have made remarkable progress in certain fields of production, are all examples of science and technology shifting from advanced regions to backward ones. From this we can derive two rules: one is that the development of science and technology depends upon an economic foundation, so that the more developed an area is the quicker will be the development; the second is that advanced technology will shift from developed areas to undeveloped areas, and will shift from advanced industries to backward industries.

From this first rule we can see the fundamental conditions for the development of science and technology. However, if we look only at these conditions and consider it as nothing attempted and nothing gained, then that would not be

Marxism but fatalism. We must look also at the second rule and use it to promote the economic development of undeveloped regions, especially to promote agricultural development, because it depends upon the labor with which to make a living and involves the most people, and it is a very undeveloped industry economically.

Appropriately Select Points of Focus and Regard Actual Results Highly

In hastening the shift of science and technology to the countryside, it is not important whether tasking is plentiful, nor how good aspirations are, for what is important is a thorough understanding: from the operation of which production links and economic projects will results be best, and which can as well constitute a driving force for agricultural production, and which technologies are both relatively advanced and can yet suit economic and social conditions of a particular time and place. Having chosen the important links, then be unremitting, pay close attention, strive for practical results, and avoid ineffective work.

From the point of view of current conditions in the countryside, we can select from various angles:

First, raw materials and products. Products such as cotton, flax, silk, sugar, fruit, etc., are still in relatively favorable positions as far as price is concerned, market needs are also quite exuberant, the light industries need them, the textile sector cannot do without them, so the state must direct a certain amount of financial resources to support their production. These kinds of products are in urgent need of advanced technology, which is quite worthy of our attention.

Second, agricultural products are best at earning foreign exchange. There are forty major types, and for minor types each area has its own specialties, and we want to develop the strengths of each in their particular products.

Third, township and town enterprises. This is the sector in the countryside where the most gains are to be made and which urgently needs expanded production and improved quality to maintain their advantages within competition. Town and township enterprises are group economies that assume sole responsibilities for profit or loss, and with the impulse of technical advances will themselves engage in the search for gain. The "spark plans" that have been organized by the State Science and Technology Commission for implementation are exactly to cope with the outcome of these needs and are certain to bring about great results. This is the growing point for rural economic development, and is certain to be successful.

Fourth, various intensive operations units in the countryside. There have already been indications along the southeast coast and in large cities and suburbs that the first steps have been taken along the path of commodity production development. There will appear in the future highly social production combinations formed from the integration of many specialist households--rural enterprises of an appropriate scale. Production organizations that possess relatively high fixed asset accumulations are just the media through which to attract new technologies. For example, cultivation

operation large households planting 30 or 40 mu will appear in the future along the southeast coast, and many of these operations households could appear in a given natural village. They will not primarily rely upon increasing labor to develop production, but will depend upon the introduction of various machinery and fertilizer, and will depend upon the introduction of new technology to improve economic results. The level of their fixed asset accumulations will improve annually, and the introduction of human labor will decline. This will then signify primary reliance upon technical advances to develop production. The four aspects just discussed are some directions in which we have choices, and they are also points of entrance for advanced technologies into the countryside. Naturally, there are also problems to be fully considered, such as using technology to support impoverished areas, where it is not that we will ignore all else, but that it is necessary to select points of focus.

Fifth, those things that are low in cost but high in profit. Production technologies themselves have production costs, and their dissemination must also consider costs. The lowest costs in modern agriculture are in improved varieties, which improve production forces through the improvement of biological properties. For various improved varieties, including good livestock, the money spent for raising them is not considered excessive and farmers more easily accept it. We have a socialist system, and where the state has assumed the majority of costs for breeding, the costs for using the results are low, so to develop an improved variety will bring excellent economic results. We have a long history of work in the selection and cultivation of improved varieties, the types of crops have been abundant, and control of modern cultivation technologies has also been rapid. There can be no limits to the development of these advantages and in keeping to our work in improving varieties.

Depend on Science and Technology, Improve Relative Benefits of Agriculture

The trend toward a constant decline in marginal profits for agriculture is nearly a world-wide phenomenon. Similarly, the results of one yuan investment in agriculture cannot compare with that in industry, nor is the labor of one person in agriculture comparable with that of one in industry. For those reasons farmers are always thinking, "I must get away from the farm!" they do not consider increasing their investment in the land. Last year, in certain regions there were instances of lower interest in planting improved varieties. Farmers are unwilling to invest money in the land, and are not only unwilling to buy fertilizer, but in some areas organic fertilizer is not even being used. Some are even unwilling to raise pigs. There is an economic rule here: when income level reaches a certain level, laborers will choose to operate in search of opportunities for earning money, and they will even so choose between labor and rest. In making choices regarding production investments, that laborers should have so many possibilities is a phenomenon of progress in society, and serves to explain why our economic standards over the past few years have actually risen so quickly.

At present, grain crops show the least benefits in the countryside. Grain is a necessary product for life, the use value of which is obvious, and when the exchange value is not so high it becomes a commodity of great contradictions.

Great quantities of it are consumed and it is involved in the national economy and the people's livelihood, so prices cannot be too high. To stabilize a basic living standard, there is no government that has not come forward to control grain production and to implement policies of protection. On the one hand, this guarantees that farmers will take in an income from growing grain that is greater than costs and that supports profits for producers; on the other hand, by having grain price supports and by storing grain, this prevents the consumer from being adversely affected by pressure from rising prices. China cannot be an exception to this. We support 0.10 yuan on each jin of grain. When the price at which farmers sell grain is high, that is "selling expensively," and when urban residents buy grain at a low price, that is "buying cheaply," and when buying and selling prices are reversed, the state will supplement. Doing things this way, in comparison with doing other things, the planting of grain cannot be planned for. When one mu of land can produce 1,500 jin of grain per year, that is a high standard, but at 0.20 yuan per jin, that is still only 300 yuan, and not counting the labor that has been involved but taking off other investment, the net income is only about 180 yuan. The total number of days spent in labor over two seasons is 100, so that is 1.80 yuan a day, and in many areas no matter what people do they can make more than this. If we figure on a basis of an average price of 0.15 yuan, even those figures cannot be met. When prices were raised in 1979, the farmers were happy. But now other things have gone up in price, costs are higher, and relative profits have declined. But can we again raise the price of grain? A rise in grain prices will lead in turn to a rise in other prices, which will generate problems in satisfaction with income levels and social dissatisfaction. If we follow up by increasing financial supports to raise grain prices, that will be difficult for the state to accept. It would appear that for the most part we must depend upon advanced science and technology. Within a certain period, use money in the areas of science and technology and in building up basic equipment. This will be the most use to developing agricultural production. We will work hard at achieving a universal improvement in the level of technology in the countryside, and when there are even greater breakthroughs in production technologies for certain agricultural commodities, this will bring greater competitive capacity to these products on the international market. It will change low income agriculture into high income agriculture, and will change the agriculture of low profit levels to agriculture of higher profit levels. Another thing we want to do is to extend the production process for agricultural commodities, bring in advanced technology, undertake rough processing, intensive processing, and comprehensive utilization, and to shift agricultural labor to the process of raising value through processing. In this way, surplus rural labor can be changed into an economic advantage, resources will have new methods of utilization, and the income of farmers can greatly increase. In the United States there are only 2 million people planting crops and cultivating, but 20 million are involved in labor for service and processing before and after production. If we can progressively develop these sectors in the countryside, we can solve a large proportion of the problems that are now appearing.

Work According to Natural Rules, and Work According to Economic Rules

In comparing agriculture and industry, the most important characteristics are that their natural production processes are effected both by natural restrictions and by economic conditions, for which we assume a "dual risk."

Agriculture in this country retains a very large empirical component, and the level of technology in many areas is not all that different from a thousand years ago. A family or household simply cannot overcome the hazards of nature, and without advanced technology and plentiful fundamental facilities, it is impossible to hold back natural disasters. In the process of agricultural production, funds and labor are relatively idle for long periods of time, and if this is not handled well it can cost money. When putting land into production to a certain degree, if technology is not advanced, then there will be a consequent progressive decrease, and the more put into production the less worthwhile it is. In industry, the skies and the earth can be dealt with, and there are fewer difficulties in this area.

We have put a lot of effort into controlling salinization, and there have been results in a small number of areas, but the majority of areas have still not changed their outlook. We have agreed that control of large areas is not economically feasible at this time. Whether we can change tactics and think of ways to seek out crops more suitable to these harsh environments, that will allow the useable land area within our 9.6 million sq km national territory to be expanded somewhat. There is a basis in the natural world for success here, for beaches have long had plants that tolerate salinity. Plants in the desert are very drought resistant, and there are penguins and krill in the extremely cold Antarctic that can survive and multiply, which shows that there are many forms of life that can generate changes to adapt to an environment. Modern science and technology, and especially with the development of genetic engineering, have already provided possibilities for using the various adaptabilities of life forms. By enhancing studies in these areas, we can certainly break through the limits of nature.

In this country, we currently divide arable land into the three classes of high, medium, and low, where two-thirds of that land is either medium or low. Low production fields are very difficult to transform into high production fields. How we are to find a better planting program is an important topic. In the past, we did not trust the traditional experience of farmers, and we did not believe in the choices farmers made in decision making, and we made a mess of things by giving the wrong orders. However, the experience of farmers also has its limits, for it is the experience of small producers; if, within a larger context, we are to arrange cultivation by making use of the environment and adapting to the environment, then we must rely upon modern science and technology, and cannot depend solely upon the experience of farmers. For example, to seek a better planting program on existing arable land with the existing level of technology, we can use computers to analyze and compare, and to calculate the reflected prices from various basic production factors, and through optimal design to point out possible choices in various programs. This kind of modern decision making method will transcend the traditional methods of farmers.

To put modern science and technology into operation in the countryside, and to progressively eliminate the technology gap between cities and villages, will without doubt be the major historical mission of science and technology leadership structures and the vast numbers of scientists and technicians. For things that farmers cannot conceive of or that they cannot accomplish, support will be sought from scientific and technical circles to help them come up with ideas and to help them accomplish things. For these reasons, comrades who are engaged in science and technology, who are engaged in the dissemination of technology, should better understand economic and social conditions, and in addition to knowledge of technology, should have a head for economics. There are broad fields of applications for science and technology in the countryside, one very important area for which is in improving the utilization efficiency for natural resources, and in seeking out various good ways in which to conserve and replace constantly depleting natural resources. This is not only a technical question, but is an economic question, and only by obtaining economic results above a certain level can advanced technology be accepted by society.

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NATIONAL DEVELOPMENTS

OPPOSITION TO SPARETIME S&T EMPLOYMENT DISCUSSED

Beijing RENMIN RIBAO in Chinese 9 Apr 86 p 3

[Report by Xiao Guangen [5135 7070 2704]: "We Cannot Be Too Restrictive of Spare Time Jobs for Scientists and Technicians"]

[Text] Since the last part of February this year, nearly every day units have sent people to the Shanghai Science and Technology Association Service Center for consultations: which scientists and technicians have joined in consulting service? How much money have they made? Reporters have overheard scientists and technicians discussing this a lot in factories and enterprises, in science research units, and in the higher institutions: current restrictions on spare time work are too numerous and too strict, they are of no use in motivating the enthusiasm of scientists and technicians, nor is this any good for the state. Everyone is hoping that leading departments can perfect their policies toward sparetime work as quickly as possibly.

Scientific and technical consulting is a new occupation that has sprung up abruptly during the reforms. Under the prerequisite that they first finish their primary work and that they not violate the rights of the host unit, scientists and technicians have made use of their sparetime to take part in scientific and technical consulting, which is good for the state, the group, and the individual. The various consulting organizations in Shanghai already constitute an important channel for developing lateral economic relations, and have solved many technical difficulties for various regions, and have generated excellent social and economic results. Based on a sampling survey, 40 yuan in profit is generated on the average from each yuan of consulting fees, while for each yuan of compensation received by scientists and technicians involved in consulting, from 200 to 400 yuan in profit is created for society.

The resolution by the CPC Central Committee regarding restructuring of the science and technology system clearly provides that: "Under the prerequisite that they complete their primary work and do not violate the technical and economic rights of their host unit, scientists and technicians may engage in technical work and consulting services in their sparetime, the income from which will remain with them." The "Circular Regarding the Limits of Policy in Ensuring the Smooth Progression of the Science and Technology System Reforms" issued by the State Science and Technology Commission in 1985 also pointed out

that "With the clear distinction that such activity is under the prerequisite of completing primary work and that there is no violation of the technical rights of the host unit, reasonable compensation for engagement in appropriate concurrent work and sparetime intellectual labor is bounded by the same lack of concern for seeking after personal gain as applies for the primary work."

However, beginning from the last half of last year, various restrictions have appeared on the participation of scientists and technicians in sparetime activities such as consulting. In general, those restriction may be summed as follows:

1. Leaders of the host unit must agree to sparetime employment, otherwise, they will be finding employment on their own, which is subject to criticism, bonuses will be affected, and advancement will also be eliminated.
2. Economic restrictions are tighter and tighter. As for example where relevant departments have ruled that the income derived by scientists and technicians from sparetime employment will be subject to temporary operations taxes, after which it will also be subject to an additional 0.7 percent municipal construction and safeguard tax based on the amount of other taxes paid. According to statistics, since the technology markets in Shanghai were opened up, the taxation rate on income from sparetime work has been raised on three occasions. Leaders have expressed worries about this, and the enthusiasm of scientists and technicians has been greatly affected.
3. Disciplinary and inspection measures have been adopted. Leaders of some units in Shanghai have made it clear publicly that engagement in sparetime work such as scientific and technical consulting is not permitted; those already so engaged must clarify their situation; those party members who do not do so will not be allowed to register during party rectification.

These restrictions have created a certain amount of turmoil among scientists and technicians, and a cold wave has broken over the once prosperous scientific and technical consulting activities. Those in charge of the municipal Science and Technology Association Consulting Center have worriedly said that even though there are many enterprises throughout the country that need consulting, scientists and technicians are concerned and do not dare take on new consulting services. Even consulting contracts already signed have no way to be completed on time because of the halt in the consulting business.

Why have these methods appeared that so restrict the sparetime jobs of scientists and technicians? Some have suggested the following analysis:

Foremost is that the concepts of leadership for some units are behind the times. They have dealt with new things and new situations that have appeared during the reforms with obsolete ideas and old habits. And they have regarded as mistaken things with which they are not familiar, to which they are not accustomed, and which are in fact correct.

Second, policy limits are not clear. Some of the policies proposed by regions and relevant departments have on occasion not been in keeping with the principles and policies of the Central Committee, and policies individually

formulated by various departments are not particularly uniform, and sometimes the policies proposed by the same department contain contradictions and differ greatly. This situation in which policies are coming from many sources without coordination has made it impossible for base units to comply.

Third, some have considered sparetime jobs for scientists and technicians as factors that affect production of the host unit. When the rate of growth for enterprise production has declined, blame is laid upon the fact that scientists and technicians participate in scientific and technical consulting. In fact, it would be hard to find a unit in Shanghai where production has declined because of sparetime employment. On the contrary, examples are numerous where development of scientific and technical consulting has motivated completion of major tasking and has accelerated rises in output value and profits. The Shanghai Textile Industry Design Academy began developing consulting services in the latter half of 1984, and scientists and technicians have actively taken on consulting projects in their sparetime, as lights are ablaze throughout all 10 floors each evening. Over the New Year holiday in 1985, many scientists and technicians voluntarily worked overtime, which both guaranteed that major tasking would be completed on time, and added to consulting income by 640,000 yuan. Gross income for the entire academy reached 3.5 million yuan in 1985 and profits were 2.06 million, which set a record.

Although many restrictions have appeared, many scientists and technicians are still willing to work in their sparetime. Problems that have arisen in consulting must be correctly resolved. The leadership and scientists and technicians of many units urgently hope that relevant departments will formulate more complete policies as quickly as possible that will actively bring on the healthy development of this business activity and that will safeguard the enthusiasm of scientists and technicians for making contributions to the drive toward modernization.

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NATIONAL DEVELOPMENTS

DECREASE IN S&T CONSULTING DUE TO CRITICISM DISCUSSED

Beijing RENMIN RIBAO in Chinese 8 Apr 86 p 1

[Report by Yi Xiao [5337 4562]: "We Should Pay Close Attention to the Drop in Scientific and Technical Consulting"]

[Text] At the China Science and Technology Association Technical Consulting Services working conference held 1-4 April in Beijing, representatives from all over enthusiastically discussed the accomplishments and problems in Chinese scientific and technical consulting services in the last two years. That science research units and scientists and technicians engage in consulting services is a new item of interest in the restructuring of the science and technology system. At this time, these people have formed a rather complete scientific and technical consulting service network throughout the country. This has trained a capable scientific and technical consulting service cadre contingent that has done a great deal of valuable work in the areas of organizing comprehensive economic decision making and serving enterprise technology. For example, the China Science and Technology Service Center has done a comprehensive scientific demonstration for an overall synchronized construction program for the coal, electricity, and transportation situation at the Jungar coal fields in Nei Mongol. This has been entered into the planning for the "7th Five Year Plan," and the northern railway construction plans have been approved and adopted by the State Planning Commission; the scientific demonstration of the water conservancy development and rational use program for the Huang He Hei Sanxia He section has received a very high evaluation by the Ningxia Hui Autonomous Region. The perspective on the development of the metallurgy industry and the more than 5,000 suggestions proposed by the China Metals Society on the major problems of technology transformation, importation of technology, and training of personnel during the period of the "7th Five Year Plan" have been largely adopted. In 1985, the five provinces and cities of Shanghai, Tianjin, Liaoning, Sichuan, and Shaanxi jointly continued 47,000 technical consulting contracts to serve small and medium enterprises and town and township enterprises, those contracts being worth 380 million yuan. Throughout last year, among the 23 billion yuan in transactions that were put into effect throughout the country through the technology markets, more than one-sixth were for science and technology consulting services. We ought to realize that in the current reforms of our economic and science and technology systems, scientific and technical consulting services have promoted lateral relations

between science and technology and production and between central cities and old revolutionary base areas, minority nationality regions, border areas, and impoverished areas, and have served as bridges and links. And they have played an inestimable role in making decision making more scientific, in hastening the transformation of science and technology into production forces, and in developing the potential of scientists and technicians.

The scientific and technical consulting that has arisen in just the last few years is just like other new things produced during the reforms: because of rapid development, certain relevant policies and management measures have not kept up with events and there have been problems in the work. But from the point of view of quantity, these problems have been only a minority of all problems, and some have even been unavoidable. According to statistics from 14 provinces, cities, and autonomous regions, such as Shandong and Yunnan, among 1,035 consultant service organizations, in the early period only 1.7 percent engaged in business, and no one was in violation of laws.

Consequently, because of these very individualistic examples, responsible departments in some areas have come up with a prejudiced view of scientific and technical consulting, either overtly or covertly considering scientific and technical consulting as "unhealthy tendencies." Some areas have drawn up various "local policies" to restrict scientific and technical consulting, which have created great pressure on those who engage in this work. For example, the effect has been great on an academy of design in Gansu Province having more than 800 scientists and technicians that because their planned tasking was insufficient developed a rather vigorous scientific and technical consulting service within and outside the province. However, under strong administrative pressure and pressure from public opinion, at the beginning of this year, the academy director of this academy was forced to proclaim that the academy was "washing its hands of it and would not get involved." The representatives at the working conference stated that through February of this year, the number of contracted transactions for scientific and technical consulting has dropped 80 percent over the same period last year and the amounts for contracted transactions have dropped by 90 percent over the same period last year. This situation of decline, a tendency that continues to develop, should attract a high degree of attention.

It should not be denied that unhealthy tendencies have made their way into the scientific and technical consulting activities of particular units, and that correcting these unhealthy tendencies is absolutely necessary. But in doing so we should make clear distinctions, should safeguard the reforms, and absolutely should not deal with new events in the reform with methods and efforts belonging to old thinking.

At the conference the representatives were unanimous in feeling that guidance, supervision, and checking of finances and taxation, auditing, and inspections are necessary in scientific and technical consulting. However, at present there is the situation in some areas whereby "new rules are meeting up with old judges." For example, for consulting services for small to medium enterprises locally determined limits are "words but no deeds," where once having acted one is engaged in production, which is not consulting services this limitation has caused scientists and engineers to complain endlessly.

Actually, for the great majority of small to medium enterprises, and especially the town and township enterprises, the general level of technology has not yet reached the stage at which problems can be solved with just a little direction, but rather must be a case of "full scale, integrated service." How we are to formulate appropriate "new rules" based on the new situations in which we find ourselves is a question in urgent need of resolution.

Reporters also learned at this conference that in large cities like Shanghai and Tianjin, where technical advantages are concentrated, scientists and engineers currently engaged in scientific and technical consulting activities are not even 15 and 20 percent of the members of all associations in the Science and Technology Association, so the potential here awaits a great effort at extraction. According to current estimates, this is not a situation of passive restraints, but of active guidance.

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NATIONAL DEVELOPMENTS

SHANGHAI S&T ASSOCIATIONS' CONSULTING SERVICES DISCUSSED

Beijing RENMIN RIBAO in Chinese 9 Apr 86 p 3

[Report by Ai Xiao [5337 4562]: "Science Braintrust Offers Suggestions and Mediates Disputes on Behalf of Economic Construction"]

[Text] Scientific and technical consulting services in the Shanghai Science and Technology Association system developed greatly last year, and they played a positive role in assisting leaders in scientific policy making, in supporting enterprises, and in improving economic and social results. This contingent of scientific and technical consultants has formed an important force with which to base in Shanghai as we cater to the entire nation.

In 1985, the Shanghai Science and Technology Association took on nearly 7,000 scientific and technical consulting projects, which was twice that of 1984; the amount of the contracts handled was 33 million yuan, 4 times that of 1984. For the 2,420 consulting projects that have been completed, the value reached 15 million yuan, which earned a direct profit to the state of 600 million yuan and provided activities fees to the Science and Technology Association of 240,000 yuan. Presently, Shanghai has signed technical consulting contracts with 26 provinces, municipalities, and autonomous regions, and has sent out more than 400 consulting service delegations, numbering more than 3,000 people, to 23 provinces, municipalities, and autonomous regions, which has shown off the technical advantages of the center and the city.

The "Baogang Changjiang (Reservoir Construction) Water Channeling Project Feasibility Consulting Demonstration" that won first prize among the first prizes given by Shanghai for scientific and technical advances in 1985 was a consulting demonstration for tracing policy making that was undertaken by scientists and technicians from many disciplines. It used scientific theories and technical and economic proofs to select and recommend that the Changjiang (reservoir construction) water channeling program replace the original engineering project that channeled water to Lake Dianshan 72 km from Baogang to one that opened up a headwater for water use at Baogang, which satisfied production needs, and which also provided a scientific basis for opening up industrial use of water at our coastal and river ports. This has strategic significance. This program allowed taking out good water from Lake Dianshan for drinking purposes for the residents of Shanghai, which had obvious social results; after Baogang had switched to using water from the Changjiang, more

than 50 million yuan was saved in project funding over the previous plan, there can be annual savings of more than 6 million yuan in shipping costs, and more than 25 million kwh of electricity is saved per year, with obvious economic results.

The Hengyang Bicycle Factory in Hunan is a test site factory for the Ministry of Light Industry. State investment has been 30 million yuan, with a designed annual production of 300,000 bicycles. Because of weak technical capabilities, confused management, high production costs, and low quality, in the 15 years since the factory had been built there had been losses over 11 of those years, until in 1984 losses reached 2.9 million yuan and plans had been made for its closure. The Yangpu District Science and Technology Association of Shanghai organized retired scientists, technicians, and technical workers to investigate and solve the difficulties. In only a year's time, product quality at this plant reached the A level, production quantities had greatly increased, costs had dropped 12 percent, and enterprise certification was obtained. In 1985, economic results of 10.9 million yuan were earned, which resulted in tax revenue of 6 million yuan. Through all of last year, about 300 factories were revived or turned losses into profits through the scientific and technical consulting services of the Shanghai Municipality Science and Technology Association system.

12586

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NATIONAL DEVELOPMENTS

POSITION OF TECHNOLOGY DEVELOPMENT DEFENDED

Beijing ZIRAN BIANZHENGFA TONGXUN [JOURNAL OF DIALECTICS OF NATURE] in Chinese
No 6, 10 Dec 85 pp 1-4

[Article by Chen Renpeng [7115 0086 7720], Chinese Academy of Sciences, Silicate Institute, Shanghai: "The Position and Function of Technology Development in the Academy of Sciences"]

[Text] The development of modern science plays an ever increasing role in modern technology and modern production. Generally speaking, the achievements of basic research must be dealt with by applications research before they can be transformed into practical technologies. This, while the achievements of applications research must go through various forms of technical development before they can then go on to be transformed into direct social production forces. Many people see technology development as the link between science research and production, which is quite appropriate. It not only links the two together, but is a two-way channel as well.

Full scale restructuring of the economic system has begun to unfold in this country, just as it creates an excellent environment for the restructuring of our science research system. At the same time as this country energetically promotes technology development, enhancement of applications research will then allow basic research to achieve a stable development. The Chinese Academy of Sciences will follow the instructions of the Central Committee in vigorously strengthening applications research, and will actively and selectively join in development, while continuing to regard basic research highly.

After several years of measured readjustment, there is increasingly clear understanding of this problem at the Silicate Institute, which is an inorganic materials science and engineering institute. Actually, research at this institute has been progressing in this direction in a measured way.

Leadership through the years at the Silicate Institute has felt that over a relatively long time, it is proper to maintain the general ratio in the three areas of basic research, applications research, and technology development at the institute at 1:5:4. Proceeding from the working foundation within the institute and the technical needs outside it, technology development cannot help but have a larger proportion. To urge that basic research be greater

than applications research would not be in keeping with reality, and for applications research to be greater than technology development is a natural thing. To generally feel that technology development is primary is a matter for the industrial departments, but for an institute of the Chinese Academy of Sciences that focuses on applications research, to increase that would be like doing something that is not one's true vocation, and if we had to do it, we would have an insufficient understanding of the importance of technology development.

In early 1984, while China's reform of the economic system had just begun and when town and township technology markets were rapidly developing, to adapt to this trend and force research to better cater to economic construction, leadership at the Silicate Institute began to realize that although the nature and function of technology development and applications research are not the same, for the kind of institute that the Silicate Institute is, we had to elevate technology development to a position of greater importance. It was then placed in equal importance with science research. We must "take on things with both hands." One hand is busy with applications research. One hand works on technology development. To this end, we immediately separately set up some of the people from the science and technology office who were engaged in management development into a technology development office. The results of this organizational measure have been outstanding. To adopt a more positive attitude toward technology development, this organizational step must be taken. The approach of organizing a development company could be used, or other methods could be used as appropriate.

In 1985, after the resolution by the CPC Central Committee regarding reform of the science and technology system, as animation in development work at the Silicate Institute developed and the sense of urgency regarding the reform progressively strengthened, the leadership came to understand even better that development is not only a problem that concerns how research at the institute is to cater to economic construction, but is also a problem that concerns whether or not this institute has any capacity for self development.

In work to develop lateral relations, the Silicate Institute has signed more than 860 contracts for the transfer of rights to technology and for consulting services with places all over the country. It has established 23 joint groups along various lines, as for example, through joint operations, joint funding, autonomous funding, etc., where the investment is intellectual or there is technology share-holding. According to the calculations of the office of development at the institute, production gross output value for 1984 could be about 120 million yuan, which would bring in more than 40 million yuan for the state in tax revenue. This not only allows the potential scientific and technical production forces that have been accumulating for years at this institute to be fully and rapidly transformed into actual social production forces, but at the same time can also form a rather stable two-way channel linking research to production.

In linking research and production, more than 150 scientists and technicians at the Silicate Institute have been hired in concurrent positions at production enterprises as engineers, technical advisers, assistant managers, vice chairmen of the board, etc., which has greatly enhanced the capacity for

technical development of these enterprises. Some new types of talent that both understand science research and production operations are currently being nurtured and are maturing. The Silicate Institute is the same as many of its siblings in that it has encountered many difficulties as it has broken the deadlock regarding the rational movement of personnel. How can it create certain conditions that will allow the transition of a number of concurrent posts into specialties, perhaps being able to open new roads for the reasonable movement of personnel, while on the other hand being able to provide and support manpower sources for research. The problems that are involved here are, of course, still thorny ones, but are worth exploring.

Through technology development, the Silicate Institute has received a gross profit of 1.44 million yuan through the first half of this year [1985], which is 3 times that of the same period in 1984. At the same time, we had signed contracts with various countries in North America and Europe and with Japan for foreign exchange values of \$3 million dollars, and it is estimated that \$1.4 million dollars can be earned during the year. The institute can then earn a certain amount of money for research development. To a certain degree, this can alleviate the financial difficulties the institute is currently faced with. If things do not go bad and there is ever more vigorous development, this financial source can be expected to become one of the chief sources for this kind of institute research operating expenses. It could provide financial support for research and at the same time a certain portion can be deducted according to rules as funds for benefits and for rewards, which could gradually improve benefits for staff and workers at the institute. The function of economic levers is becoming greater, the significance of which cannot be underestimated.

The outlook for technology development work at the Silicate Institute is a good one, for supply cannot keep up with demand in the technology markets. The institute director said early this year that: achievements we have had in the bag have now all been brought out. The office head of the office of development said: we have now reached the point where "it can be seen that we're married by the shape of our stomach." For achievements that have not yet come out, people are predicting that the majority of technical achievements that will be transferred outside the institute from technology development inside will be the accumulation of years of research. As for example the niobium-acid-lithium crystals and devices jointly developed and produced for color television with the Deqing Electronics Materials Plant in Zhejiang, which beginning in 1973 were the primary focus of the manual crystal laboratory. Or like the scintillation crystal germanium-acid-bismuth used in high energy detectors that is currently undergoing testing, which as a crystalline material began to be studied 5 years ago in response to the needs of the new CT technology in medicine. But what is used as the techniques and methods for crystal growing can be traced back 20 years, when the foundation began to be laid by techniques for the growing of compound mica. To maintain the good prospects for development, there must be sufficient reserve strength. It will not work if there is not sufficient research in reserve. Institute leaders have felt deeply that our reserve strength is not sufficient, and that we must "prepare for a rainy day" and not "wait until thirsty before digging the well." We must be prompt in adopting effective measures and vigorously strengthen applications research to develop and prepare the reserve strength,

for otherwise in less than 2 or 3 years we will be bogged down in passivity, which will bring on a crisis. Regarding existing arrangements for applications research, it is necessary that these be earnestly reevaluated in light of new trends, and that necessary adjustments be made. This new understanding of the importance of applications research and of the urgency of renewed consolidation is quite different from the starting points of the past. It is possible that this is motivated by the needs of the new operations systems as established in response to reform of the science and technology system. Ten percent of the activity at the Silicate Institute is basic research, and under stimulus by current trends in technology development, research personnel in this area will naturally feel somewhat insecure. As for example where a comrade who is engaged in using the Monte Carlo method to simulate crystal growth said worriedly at a conference, he has the feeling that his work may be cut off at any moment. Institute leadership has not forgotten the many lessons of the past, which clearly indicate support of work of this kind, and so have adopted measures to allow them to continue on without worry. At the Silicate Institute where applications research is of primary concern, there may be the need in the not too distant future to increase the proportion of that research, which shows its greater importance. This is not even a matter of choice today. If the position of technology development is not appropriate, and its relations with applications research and basic research are not handled well, history will be sure to lay blame. This is not something that can be ignored.

Relations in these aspects should be gradually rationalized in the reform. Trees have roots, water has its springs. Research should be the back-up of today's development work, and the reserve for tomorrow's development work. Technology development will enable applications research to be verified and rewarded. Both research and development ought to constitute complementary relations, that is, relations of mutual survival, intertwining, and mutual stimulation. The shoots can already be seen, so experience should be accumulated and understanding deepened in order to realize as soon as possible these favorable cycles.

The characteristics made up of proportions and relations between the three types of work in the Silicate Institute, as well as discipline and specialty structures and various operational patterns, have already allowed this institute to break through at an early stage the traditional pure research models. This institute is already a comprehensive institute that focuses on applications research, but also stresses development. We believe that an institute with this sort of blend ought to be quite representative of the Academy of Sciences. If there could be a large institute established on a solid foundation of applications research and that also had a strong capability in technology development, that had high standards of science and technology and yet also great energy for self development, the Chinese Academy of Sciences would certainly be greatly strengthened in its capacity to solve major science and technology problems in national economic construction.

Naturally, the Academy of Sciences should not stick to one pattern in allowing its affiliated institutes to be strongly individualistic in meeting the needs of science and technology and of social and economic development. Some stress basic research, some emphasize applications research, some focus on technology

development, while among all these is the institute that is a blend of all. At present, at the same time that the Academy of Sciences is vigorously strengthening applications research and steadily developing basic research, as far as technology development is concerned, as long as the road is correct there is no fear of doing too much nor of repeating, and this is especially true of technology development that can take laboratory work as a back-up and that has the capacity to enter and compete in technology markets. What we mean by the road being correct or not is mainly whether relations among the benefits to the three parties of the state, the group, and the individual are handled properly, whether or not there are instances of seeing only profit and not significance. Resolute measures should be adopted, including strict elucidation of projects and strict project accounting, which as quickly as possible will urge the Academy of Sciences to produce a group of development model institutes that have the vitality for self development. When there is a great deal of technology development work, when technology development type institutes are more numerous, this will not necessarily affect the development of basic research and applications research. On the contrary, it is entirely possible that this will be quite beneficial to the invigoration of the Academy of Sciences. Some institutes plan for 40 percent basic research, but in fact may have only 20 percent. Some institutes plan for 50 percent applications research, but may actually have only 30 percent. Current problems in basic research and applications research at the Chinese Academy of Sciences are possibly not for the most part affected by the amount of development, but possibly are mainly due to topic selection and the quality of cadres. As long as technology development work is not fighting with basic and applications research for operating funds and for food in the communal pot, then with great courage the reins should be slackened and research personnel encouraged to leave the Academy of Sciences and go to the technology markets to put their hands in. In summary, I believe that under conditions that do not affect the development of applications research and basic research, the potential that can now be extracted from within the Chinese Academy of Sciences and placed into technology development to make even greater and more numerous contributions to development of our production and to the prosperity of our economy is quite considerable. Looking at the Academy of Sciences through the eyes of the Silicate Institute, I feel that the Academy as a whole should grab hold of things with both hands, should rationalize its research and development relations, should set up complementary relations between these two aspects, and would by doing so avoid competitive and debilitating relations.

In light of current trends regarding open-door policies and large scale importation of foreign technology, there should be a full evaluation by this Academy comparing research and development. The Silicate Institute has been engaged in the study and development of optical communications and light-guided glass fibers for nearly 10 years now, and although for some years now many major scientific and technical achievements have made their way into factories, this cannot satisfy the demands of construction in optical communications engineering. The state must still spend large amounts of foreign exchange through the industrial sectors to bring in technology from abroad, especially to buy new technical equipment. Through accumulations of many years of research, although the Silicate Institute could fulfill certain functions in the aspects of feasibility studies and negotiations and assimilation, it has fallen into passivity. This one case is quite

instructive. If things go on this way, it is possible that our Academy and the nation could be faced with this grim situation with research and development related to the new technologies of important future projects. If the past is not forgotten, it is the teacher of the future. We absolutely cannot passively hold our own, and even less can we blame everyone but ourselves, but rather should revive ourselves and get active. We should strive to base ourselves on autonomous research, actively joining in development with foreign countries, and should strive for higher starting points and higher speeds for development. Of course, we should not get rid of joint operations within the Academy and within the nation. Explorations have already begun on this aspect, but for the time being there have not been successful experiences. It is my belief that technology development of this sort ought even to be more active than at present. And of course we want to fully utilize beneficial conditions in our institute to select carefully the objects of our attention, not wanting to take risks that are too great.

Many institutes within the Academy of Sciences are building affiliated development and experimental base areas. With the support of the state, this Academy is still in the process of building some experimental base areas that are Academy affiliated. As for example, the experimental base area for new materials in chemistry. Work at these experimental base areas, and especially the work at Academy affiliated base areas, should certainly be closely integrated with relevant research, and should develop in concert. Disjointedness should certainly be avoided.

Applications research and technology development at our Academy should be more academically nurtured to the greatest extent possible from the basic research at this Academy, and there should be greater mutual relations and mutual support in work. If applications research, technology development, and basic research at the Academy of Sciences can be well integrated, they will form an organic system that is full of vitality. Then, the Academy of Sciences would take off like a tiger with wings, and would be resplendent in our drive toward modernization. For these reasons, I believe the view that holds that we must split the Academy into two academies, where one deals with the basics and the other with applications, should not be adopted. It would be best to organically integrate these things and truly develop the comprehensive advantages that are present.

Discussing the relations between these three areas from the point of view of technology development, exploration of this problem can certainly not be replaced by a discussion of problems created through the joining of different disciplines and different specialties that cut across projects, institutes, and academies. In the development strategies for our Academy, problems in these two areas should actually be solved at the same time. Recently, the Academy has been in the process of organizing nearly 10 institutes of different types and different specialties to take on research and development of optical storage technologies, with the hope that they can create an example of how to make the most of the comprehensive advantages of the Academy of Sciences in these new times.

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NATIONAL DEVELOPMENTS

INTEGRATION OF JILIN S&T, ECONOMY DISCUSSED

Beijing RENMIN RIBAO in Chinese 9 Apr 86 p 3

[Report by Wang Jinghe [3769 2529 0735]: "The Integration of Science and Technology with the Economy Moves Toward a Systematic Institutionalization"]

[Text] In treating promotion of the integration of science and technology with the economy as an important strategic measure for revitalizing the economy of the entire province, Jilin Province over the past 2 years has put into effect a series of reforms that promote continuing steps toward systemization, institutionalization, and regularization for this integration. They have worked to accelerate the transformation of scientific and technical achievements and the development of local economies.

At present, the situation in which provincial science and technology is divorced from production is already changing, and the spontaneous, temporary, and disorganized conditions of the last 2 years are being transcended as more and more science research and teaching units have established long term stable cooperative relations with the economic sector and with production enterprises. According to statistics, there are more than 1,300 science education and production joint operations and integrated units throughout the province at present, 89 of which are affiliated with commonly funded, mutual risk, shared profits integrated bodies. Of the scientific and technical achievements that could be disseminated from the 796 projects that have been obtained since 1984, the achievement transformation rate has been 71.6 percent.

There are 172 independent science research institutes and 45 institutions of higher learning in Jilin Province, and the scientists and technicians are among the front ranks in the nation in proportion to the provincial population. To transform the scientific and technical advantages into economic advantages, in 1984 the province arranged for 10,000 scientists and technicians to go to factories and to the countryside to develop technical consulting and trouble-shooting. It was also arranged that persons in charge within responsible sectors of the economy and from nearly 1,000 enterprises would visit higher institutions and research units, all of which had outstanding results.

Jilin Province has adopted a series of measures to further the integration of science and technology with the economy. First of all, they have changed the situation in which science and technology is controlled solely by the science and technology commissions, and have set up leadership structures for direct guidance by the provincial government and for the integration of science and technology with the economic sector. Science and technology leading small groups have been set up in the province, the heads of the groups being comrades of primary responsibilities in the provincial government, and the provincial government directly organizes and coordinates major problems that concern various bureaus.

In addition, they have also changed the planning and management systems to promote integration from various angles. In the areas of planning and funding structures, they have focussed on arranging developmental research. There were 351 projects as part of provincial planning last year, 271 of which were development research and applications that could be expected to be useful in the near term.

Third, they established a system for the management of scientific and technical achievements and a responsibility system for transfer and dissemination. The provincial science and technology commission is in charge of registration of scientific and technical achievements throughout the province, and for statistics, gathering, and shipping for achievements that can be sold, and they will also take charge of dissemination of achievements in the areas of culture and education, hygiene, and agriculture together with relevant bureaus; provincial planning and economic commissions will be responsible for the dissemination of achievements in areas like industrial transportation, capital construction, and commerce with relevant offices throughout the province.

At the same time, they have called get-togethers, networking meetings, and specialty topic conferences, and have established channels for relations between research and teaching units on the one hand and economic departments and production enterprises on the other.

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NATIONAL DEVELOPMENTS

SPECIAL FUNCTIONS OF RESEARCH ORGANIZATIONS EXAMINED

Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 2, Apr 86 pp 33-35

[Article by Xu Qingrui [6079 1987 3843], Zhejiang University: "Exploring the Special Functions of Research Organizations"]

[Text] The resolution by the Central Committee regarding restructuring of the science and technology system opened a broad new future for the development of China's science research mission and greatly strengthened the vitality and impetus within science research organizations. Catering to society, there is already a tendency for branch research units to be progressively constituting independent research development entities. To adapt to this change, research units must strengthen their science research management, one point in which is very important, namely, improving the quality of research personnel, that is, to select and supply various types of people who are suited to engagement in research activities.

With what qualities and functions should research personnel be provided? This is an important question worthy of a thorough analysis.

Whether a research organization can be truly successful, whether it can produce research achievements with outstanding results, depends to a great degree not only on the scholastic standards, sense of commitment, and strong sense of responsibility of scientists, but also on whether the organization itself can provide personnel who have many important special functions (of course, these special functions could also be present in the scientists themselves).

Five Important Special Functions

To effectively accomplish science research tasking and to allow achievements to be broadly applied, first level research organizations must also provide the following five functions in addition to providing research talent with high standards:

1. The function of generating new thinking. The ideas for new principles, new products, and new techniques are primarily obtained through analyzing information regarding markets, technologies, and techniques. If the function

with which a research organization generates new thinking is vigorous, there will be sufficient innovative vitality within this organization and everywhere will be dynamic.

2. The function of start-ups, or we could say the spirit of entrepreneurs in the front lines of science and technology. This is an opening up and maintaining function. When a new idea has been tested and verified, then difficulties should not be allowed to stand in the way, but ways should be found to realize that new idea. Actually, realizing new ideas always requires more effort than does generating new ideas. Without the innovation of entrepreneurs, the spirit of willing to take on risks, and firm resolve, new ideas would never get off the ground.

3. The function of leading projects and coordinating relations between people. Lacking the leadership function, there is no way to coordinate and accommodate research personnel, a tendency that would certainly affect the quality, standards, progress, and results of science research achievements.

4. The function of collecting and facilitating information. In this information explosion world of today, science research must open the channels for information and relies upon broad-based information processing. It must not only transmit outside technical information to the scientists and technicians in its own unit, but must also free up information channels within the unit. If this function is not respected, it can very well lead to the situation in which projects have gone on for a half year before it is discovered that the original project under study is out of date or backward.

5. The function of guiding and teaching young scientists and technicians.

A number of the five functions just mentioned are unique and unorthodox.

By unique we mean that these functions are special functions and that they are not things that just anyone can take on, that require people of a certain quality and accomplishment to take charge of. Generally speaking, from 70-80 percent of scientists and technicians cannot successfully take on functions in these areas, rather only a few talented scientists and technicians can personally take on different functions and be effective in these different aspects.

By unorthodox is meant that these functions are difficult to specifically explain and provide for in a working context, nor can they be included within the rules and regulations of the organization.

Although the five special functions described above are not science and technology itself, they are all organic components of the science research and innovation process, ignorance of which would bring unfortunate consequences to science and technology.

Those Responsible for the Function of Opening Up Information: Technical Link Personnel

Scientific and technical activities are "flows" that generate knowledge and that continually develop. This "knowledge flow" is also an "information flow." Science research activities are processes that continually generate new knowledge, and that at the same time are processes that continuously handle and process information. For this reason, scientific and technical activities are essentially an information handling activity.

The first question that scientists and technicians must face is obtaining and resolving the various information needed to carry on scientific and technical activities. The function of collecting and circulating information has become the key to whether research organizations can obtain results.

The function of getting information through is generally taken on by technical link personnel in the research organization. We can also call technical link personnel "technical key personnel" or "technical core personnel," for they are not appointed by higher levels, but are instead come to be naturally within actual work.

Actual practice has shown that whether they are large research units or are small project groups, in information contacts networks that overlap horizontally, it is always or nearly always possible to discover the "link personnel." They bring in outside technical information and broadcast it within the particular unit, which allows the transmission of technical information to change from a single shift to a process of a "two-step shift." This process of a "two-step shift" has produced unexpected results. Through the process of "absorption--assimilation--dissemination," outside information has been allowed to become easily absorbed "jargon" that integrates particular units and professions, for which reason the transmission of information has become even more effective. The following diagram is a sketch of the information "two-step shift."

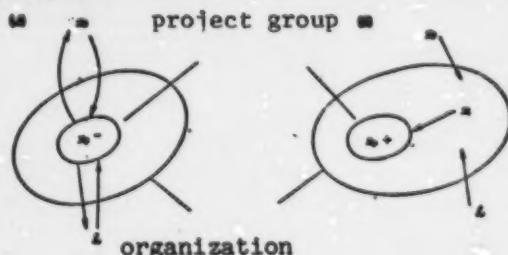


Diagram of the Two-Step Shift of Information

where, X_0 : scientists and technicians outside this organization
 X_p : members of project groups that need information
 X_1 : technical link personnel
 L : written information
 $+$: good results
 $-$: poorer results

Capable technical link personnel can cut across many of the boundaries of information links to act as full links in the transmission of external information.

The Characteristics of Those with Special Functions

In a research organization there should be people who have various special functions, which will allow them to each develop his unique function, where each will develop his strengths and supplement his weaknesses. This will allow the group effect to be fully played out, ensuring smooth completion of the research mission.

Those responsible for special functions have distinct characteristics in all aspects.

A creative scientist or technician good at generating new ideas is a special talent, and needs to be selected for nurturing and must be managed with special methods. For example, in arranging tasking we cannot be too strict in scheduling, but should provide adequate time to allow them to learn of other information and to be innovative in independent thinking. In addition, we should allocate to these people of unique creative abilities work at a higher level of creativeness, and also allow them to work on their own. They are always specialists in one or two fields, good at creating concepts, theories, and abstract thinking, fond of making contact with new things and using different ways to solve problems, and good at seeking out breakthroughs and working innovatively.

Supporters of technology, entrepreneurs with an innovative spirit, are also a kind of specialist talent. They are creative, but are even better at promoting creativity. They are suited to the transmission and broadcast of new thinking and products, and they are even more suited than scientists and technicians in their enthusiasm for dissemination and innovation. They often take risks, can win over resources, handle affairs in a decisive manner, have a wide-ranging enthusiasm, and have a great capacity for supporting other people.

Those who can effectively guide and manage projects are yet another type of person. They are people with an ability to organize and who are good at coordinating different types of people. They understand and are familiar with many disciplines, and know as well how to fit in, are good at using information for decision making and for solving problems. They are quite sensitive to the needs of others, can encourage others, and can make work proceed effectively.

Technical link personnel are both links by which outside scientific and technical information is brought in and are links through which scientific and technical information from research and development sectors is transmitted. They are highly technical, and through the various means of journals and conferences can keenly obtain relevant outside information, and they take delight in passing on information to co-workers in their organization, are fond of getting close and cooperating, are willing to help others face-to-face, enjoy high prestige among colleagues, and can informally coordinate personnel, all of which makes them an important source of information.

Those who are in charge of the guidance and teaching functions are, generally speaking, older, experienced project guidance personnel or are people who

earlier undertook ground-breaking work, and they are more amiable and easier to approach than the average person. Those persons at higher levels and of earlier generations can guide and teach the normal members of a group and can also carry on a dialogue with leaders at higher levels. These activities create important conditions for the effective progress of new thinking and new projects. When leaders of research units can be coordinated uniformly with those who academically are of an earlier generation, then these units can be successful.

The facts have shown that when many research units have produced few achievements and have low results, a primary factor is that their organization has lacked personnel with the special functions just described. This point should elicit our attention, and should be studied and resolved conscientiously in research management.

12586
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NATIONAL DEVELOPMENTS

SYSTEM OF RESEARCH INSTITUTE MANAGEMENT PROPOSED

Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 2 Apr 86
pp 41-45, 35

[Article by Huang Desen [7806 1795 2773], Ministry of Aeronautics Industry, Institute No 601: "The Establishment and Strengthening of the Management Systems in Science Research Design Institutes"]

[Text] In highly complex societies, due to increasingly narrow divisions of specialist labor among individuals and organizations as science and technology develop rapidly, the success of a complicated engineering production design depends not only upon the extent of the science and technology potential of research departments, but also upon the standards of organizational management. Because of constantly increasing demand for new products in the marketplace, as well as a quickening pace for the renewal of products by advances in science and technology, there is a similar demand to adopt more effective management and optimal organization.

If a department is to pay close attention to science management, it must pay close attention to the establishment and implementation of science research management systems. "You can't make a circle without a compass" is a simple truth the ancients derived from actual experience. How science research management systems are to be well established and implemented is also closely related to whether the management concept is scientific and whether measures are powerful. How each research design department is to enhance science research management based on the characteristics of their own work has become a question of joint concern for every management person, especially because the development of reforming trends has been so quick, and science research design is currently faced with the challenge of the new technical revolution and increasing fierce competition. This paper attempts to analyze and explore some knowledge and methods from the actual experience of recovering, rectifying, and establishing the vigorous development of a science research management system for the Aviation Model Research and Design Institute in the process of model research and design during a period of quality consolidation and full-scale enterprise rectification, presenting this for discussion.

I. Primary Characteristics of Aviation Research Design

The Aviation Model Research and Design Institute is a national defense research unit, the primary missions of which are to study and design new model aircraft, and to provide modern military weapons and equipment (products) for troops (users), both to enhance the real strength of national defense. There are many differences between this and the civilian industries.

1. The aviation industry is a typical type of technology intensive industry, where the manufacturing technology of modern aircraft is extremely complex, it is very exploratory, and there are many uncertain factors. Aircraft research and design is itself a process directed toward design goals that is constantly generating science research reports (information), and is a process that constantly resolves uncertain factors as design and experimental work unfolds. Therefore, to a great degree its production and development depends upon constant control and operation of the newest scientific and technical achievements.

2. The objects of research design are very comprehensive, systematic, and task oriented and they are part of the coordinated problem solving of many disciplines. The cooperative relations are not only between the departments of the aviation industry, but are broadly connected with various other departments in the national economy. And the concept of time in the cooperative mission and the requirements of technical goals are both very high, so there must be strict organization to fully ensure coordination.

3. The quality of aviation products have an especially important significance that affects the outcome of war and human safety. For these reasons, there are many quality goals, requirements are high, control is strict, and there must be full scale quality control that is a "total process, done in stages" from the stage of feasibility demonstration to the stage of production of the final model using high quality science research to ensure the manufactured quality of the new machine.

4. Development and production expenses are great and turnaround is long. Because aircraft construction is constantly increasing in complexity, there is more equipment, techniques and technology are constantly improving, and the pace of technology renewal is so fast, which means that development and production of new machines requires large expenditures of financial, material, and labor resources. Development expenses for modern fighter aircraft can range from several hundred million yuan to billions of yuan with a development time as long as 10 years. Obviously, the problems of improving economic efficiency and reducing development times are very prominent.

We can see from this that the management task for the Institute of Aviation Research and Design is an extremely onerous and complex one. It is just as a foreign management authority once said, "The success or failure of a complex aircraft production design might depend more on the 'management gap' than the often mentioned 'technology gap.'" Consequently, the analysis and exploration of how to manage the Institute of Aviation Research and Design well is not

only very important for the aviation industry sector itself, but also has significance as a universal model for other defense industries and research and design institutes in the national economy.

II. To Manage Science Research Well We Must Change From Administration by Individual to Administration by Law

For more than 30 years, "leftist" influences and interference and destruction by the "gang of four" forced China's aviation industry to proceed along a precipitous and tortuous path. The collective result of these conditions can often be seen in the passive aspects and instability in the problems of product quality and of economic results for enterprises. A few examples will illustrate:

1. During the periods of the "great leap forward" and the "10 years of upheaval," because of blind pursuit of high production value and high quotas, undertaking the so-called "eradication and rebuilding," opposing "pressure from management obstructions," eliminating checks, and getting rid of a reasonable system of regulations, and consequently bringing on several disasters over that period involving quality reversals.
2. Reviewing the history of new machine designs, valuable time has been lost in vain due to hurried project starting without full demonstrations and insufficient preparation of conditions, which ended prematurely and resulted in the expenditure of large amounts of financial and material resources, and which has delayed the course of aviation science research development.
3. Quality accidents that have happened and work efficiency that has not been high is directly related to disorderly management. If the responsibility system is now not strict and responsibilities are not made clear, as soon as there are regulations to be followed and violations are investigated, the situation is sure to take a clear turn for the better.

As we have just described, the effects of whether or not there is scientific management are extremely far-reaching. Overall, if policy making is in error, this will affect national economic development and the success of undertakings; in the near term, it will affect the quality and results of a particular job or product. And the position of science management and the degree to which it is respected depend first of all upon national principles and policies, and for a particular department depends first of all on the management concepts of major leaders and the degree of perfection of the system of rules and regulations.

There are two management concepts that must be reformed.

One is doing things by administrative order or the wish of a high official. When in management there are no clear working procedures or responsibility system, to which is added the fact that certain leaders have no specialty but like to "supervise," and that in major policy making as long as a minority of leaders have the final say, then as soon as gross errors are made, there is no one to take responsibility nor any way in which to assume it.

The other concept is the use of technology to replace management. For some comrades who have taken leadership positions from the ranks of professionals, it is easy to revere technology over management because of their personal experiences. They are extremely sensitive to the contradiction of the technology gap but easily neglect the problem of the management gap. They see only the restrictions in the system of rules and regulations, and cannot see their functions of promoting and guaranteeing. Moreover, when there are conflicts between science management and the thinking, methods, and customs of traditional management, or with the management system, it is easy to pit technology against management and to see science management as an added burden and as an "elastic" assignment.

Comrade Deng Xiaoping has clearly pointed out, "Do not change as leaders change, and do not change with the changes in views and objects of attention of leaders." He has urged on several occasions that "We must review both sides of our experiences and must recover or establish a system of rules and regulations." These words are in light of historical experience and get right to the heart of enterprise management. Advanced industrial nations see a system of rules and regulations as the laws of an enterprise, as the basic condition under which they realize management functions, and also consider the system of rules and regulations for enterprises in the category of management standards. Consequently, they allow the task of enterprise management to be ordered, systemitized, and standardized. As everyone knows, Japan has taken management standards as the basis and criteria for promoting full scale quality management, which has then allowed product quality and management efficiency to surpass quickly that of the United States. And they have effectively corrected the abnormal phenomenon of the past which held that "as long as people stayed there is order, when they leave there is chaos" and allowed the transfer of individuals. Therefore, to strengthen science research management, we must change the "control by individuals" to control by law" and establish a set of laws and regulations for effective science management.

To emphasize "control by law" is definitely not to deny the subjective dynamic role of people. On the contrary, laws and regulations can allow all levels and aspects to operate in accordance with unified laws, which will guarantee that enterprises can operate regularly, can realize effective control, and can guarantee coordinated work. In this way they can even better cooperate in different tasks, each getting what it needs.

A system of rules and regulations is a specific realization of the integration of management concepts with actual practice. With a scientific management system, we can accelerate the transformation of advanced science and technology into useful products and social wealth.

Practice has shown that the management methods of advanced enterprises always closely integrate advanced science and technology with scientific management methods to act as two vehicles for carrying the rapid and steady development of the economy. And on the contrary, units of deficient quality, low efficiency, or unstable results either have backward management methods or do not pay close attention to science management.

III. The Basic Requirements for Formulating a System of Science Management

1. Directive

A science management system is basic rules and regulations that use policies, that organize, guide, control, and coordinate science research and design activities. Consequently, it must be a review of experiences from the actual practice of research and design work, as well as a rational development of perceptual knowledge. What kind of system a department or project actually sets up, what problems each system must solve, should proceed from reality, should be considered in total, and should be arranged in a unified manner. Judging from the present, we should first of all focus on the tasks of responsibility systems (and especially the position of important interfaces and the division of labor problem), work procedures, working methods, and work standards. After the system has been established, we must emphasize thorough implementation, where leaders at all levels serve as examples, take the lead in implementation, and where management departments make investigations, for otherwise if a system is good but is not implemented, it is a mere scrap of paper.

2. Systematic

A science management system must be suited to the characteristics of aviation research and design, and must be worked out as a whole. Development of modern aircraft is a complex systematic project, for every link, every job, and every department must constitute a system that is a coordinated whole in accordance with the principles of a system project, where there is mutual coordination both vertically and horizontally. For example, vertically, we should establish a technology management system for each design stage according to the requirements of the order of model design; laterally, we must set up full scale systematic provisions for management of each function, such as for planning, quality, economics, education, archives, and information. The organic integration of the vertical and horizontal constitutes matrix management of the whole model design.

3. Integration

Each particular matter, each influential factor, each explanation, and each style of form that is relevant to the system should be made provisions in a logical order. In general, a larger system would include: basic principles, job tasking, assignment of responsibilities, methods of implementation, and various explanations and forms, for which we should strive for integration, clarity, and ease of thorough implementation.

4. Suitability

Research and design is a development activity for new technologies, where conditions are constantly changing. To allow research management to be regularly situated in an optimal state and to receive the best management results, the research management system should be appropriately revised and perfected as it adapts to objective changes. Therefore, the science management system is not like the system of regulations for production

departments, which can be relatively stable for long periods. For example, with the problem of division of responsibilities, because of the constant development of design technologies and the appearance one after the other of new specialties, former divisions of labor must be appropriately adjusted and reclarified; design sequences and management methods must be progressively detailed, revised, and replenished according to new experiences and new situations. Therefore, we must regularly gather reactions and questions from all areas and suitably revise things to guarantee the active effectiveness and suitability of the system of rules and regulations. We cannot have the same system for several years. Of course, neither can we keep changing all the time, to rashly deny the system that has been established. Major alterations or modifications should be carefully studied, for overall we want to maintain a relative stability. Managers must analyze in detail how these two extremes are to be properly handled.

IV. The Categorization of Research Management Systems

To aid in the goals of management, systemization, and improvement in completeness, we have derived five categories based on the characteristics of design management and specialized subject matter (see table at end of paper).

1. The Responsibility System

This provides the working scope for each department and each type of personnel and the responsibilities that should be fulfilled, which include:

Organizational structure-- the organizational format of the management system and corresponding subordinate relations;

Range of job responsibilities-- the working scope of each department. We must clearly formulate and coordinate the working relations between interacting parts.

Personal responsibility system-- the job responsibility that all categories of personnel should assume. This may be carefully separated into a technical responsibility system, a quality responsibility system, and an economic responsibility system, in which the working core is the technical responsibility system at each level of the chief design engineer system, and which is the primary object of research management.

2. Model Design Management

The various management systems directly related to model design technologies. They are generally listed under the categories of research programs and specialist categories, as for example, overall coordination, weight control, etc.

3. Management of Special Technologies

The management structures of each job and the management system, regulations, provisions, methods, and detailed rules for the implementation of the management functions of various specialties, as for example planning management, quality management, economic management, and education management.

4. Work programs

When taking any particular job, make strict provisions for the work to be done according to the steps in the job and their sequence. This allows for modularity, rules, and sequences, where a work process cannot be disregarded, reversed, or left out, and by which the best quality of work and optimal work efficiency can be had.

For design departments, those that are most important are the various design sequences, experiment sequences, calculation sequences, and work regulations.

5. Work Standards

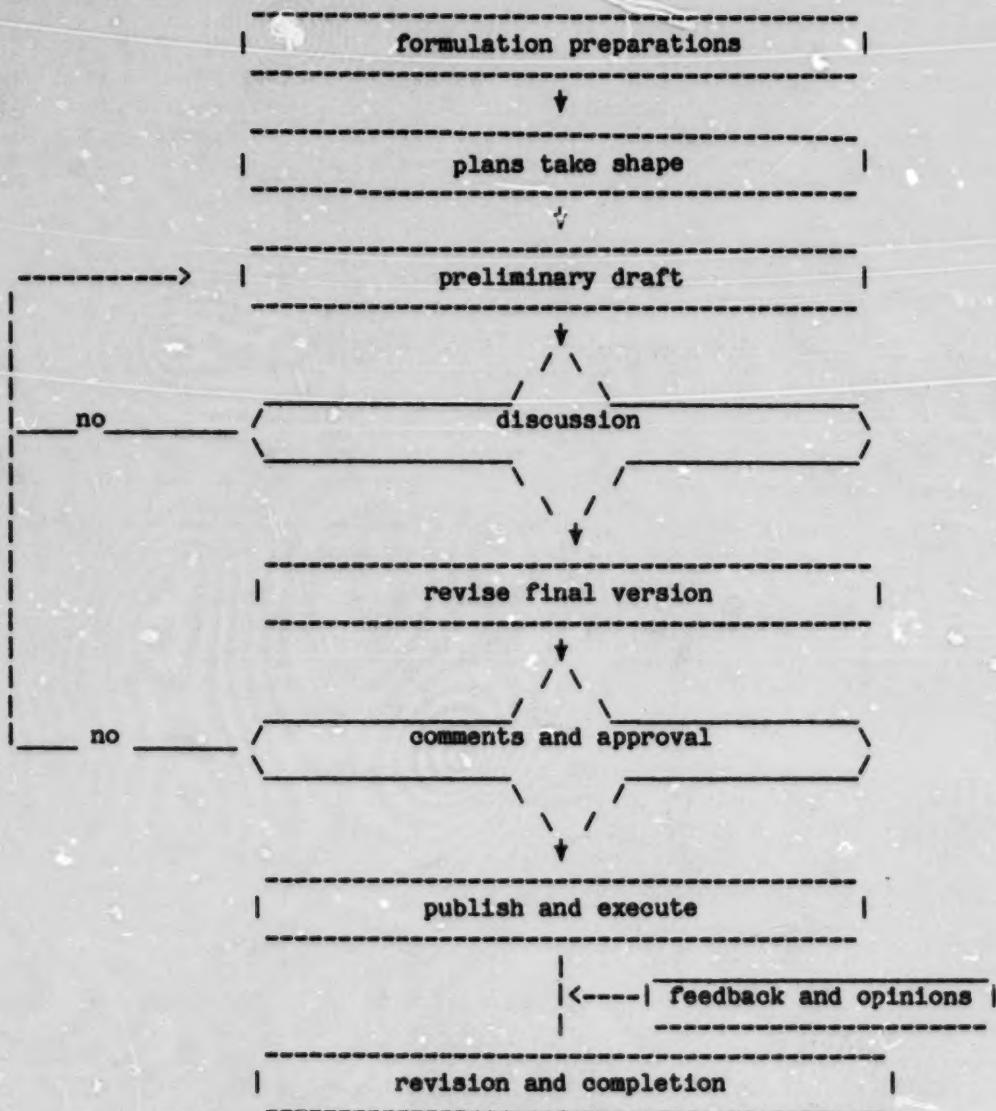
These are the evaluation norms for judging work quality, and are also examination standards. For example, when completing a particular design task, the stipulated level and degree or job target should be attained, for which should be sought quantified, statistical, or comparable levels, such as 'superior,' 'excellent,' 'qualified,' 'not qualified,' etc.

The various categories of research management systems just described are mutually related and mutually complementary, but each has its leanings and characteristics. To allow management standards to become gradually systematized, I feel that just how these things are reasonably categorized is a new topic that should be explored for standardized work.

V. Drawing Up a Work Program for Research Management Systems

To draw up a research management system according to a management standard model we must unify the provisions of the format, sequence, and conditions of the formulation and of the formulation requirements. And we should also determine a department head formulation plan and organization coordination.

The sequence I have worked out for research management systems is as shown in the following diagram.



Flowchart for Make Up of a Research Management System

1. Preparations for formulation: this primarily determines the material to be worked out and organizational preparations for the formulation work, as for example, the questions of what to write, how to write, and what will be written by whom.

2. Forming the plan: based on the proposed topics for formulation, and after receiving approval from the leaders in charge, list formal work plans. Planning topics are to be unified and arranged by the management department in charge, to be assigned at the beginning of a year or any appropriate time, and if a supplement is needed, then that can be added provisionally.

3. The preliminary draft: the standard of the initial draft plays a big part in the quality of the document, for which reason it is best if the drafting is the responsibility of leaders themselves or of key technical cadre. By collecting together their many years of work experience, this will ensure the feasibility and completeness of the system. The drafters must have an overall viewpoint and scientific attitude, and must beforehand diligently gather relevant materials, broadly elicit opinions, and review experiences and lessons; the materials that are included should be clearly specific, thoroughly feasible, and verifiable; certain problems that for the time being cannot be determined should not be forcibly included; the writing should be complete, concise, and coherent.

4. Discussion: relevant departments and personnel should be organized into full scale discussions according to the material in the documents and to the areas covered by it; major problems should be discussed over and over, seeking for unanimity; the person in charge should prepare well, should explain the situation, and should propose the major questions for discussion.

Discussion is not just for unifying knowledge, but for enriching the material. It is also an occasion for explanation and a deepening process, with great advantages for the future implementation.

5. Revision and the final manuscript: here, the opinions from the discussion should be accurately considered, and the language and format should be standardized and unified. Problems that have not yet been solved should be referred to the leadership for a ruling.

6. Comments and approval: the drafters should try to coordinate matters that involve relevant units, and then the two or more parties should agree on a time for signing to show joint responsibility.

Attention should also be paid to coordinating a joint signing when the leadership is to approve, so that the approval can be released.

7. Publication and execution: through the unified release by relevant management units, this will allow the document to be easily implemented, and the area of distribution should be as broad as possible, with one copy for each person likely to use it. The formulating unit should proceed from the idea of developing the task of that department and take responsibility for organizing implementation of this system, and should be responsible for solving and handling problems that arise during implementation.

8. Revision and completion: opinions and questions should be regularly solicited and the document periodically put in order and revised. There should be emphasis on investigating and the controlling the following problems:

a. The situation under which the system is implemented and questions that arise therein.

- b. Whatever rules need revision and completion should be revised before they can be considered complete;
- c. To improve the effects of implementing this system, what other opinions and suggestions are there;
- d. What opinions and requirements are there regarding management in the research management system, and how can the results be made even better.

In summary, the "form-- implement-- revise" process of this system is an ever deepening and progressively improving process in the work of research management.

VI. A Rudimentary Understanding

- 1. We should continue to make great efforts at publicity, at improving understanding, and at improving efficiency.

There are at present difficulties and obstacles to the promotion of research management, but the confidence and zeal of leaders at all levels and of vast numbers of research personnel is still on the upswing. Because the work positions of research and management personnel and their sense of mission differ one from the other, it sometimes happens that certain contradictions are common occurrences. Because research personnel are most concerned about opening new fields in science and technology, while management personnel want to accomplish and organize their management tasking, this greatly limits making the most of the benefits from resources, but they can certainly work together at a common goal.

If we are to allow research management to develop thoroughly and protractedly, the main problem at present is still in improving ideological understanding. We should begin from two aspects: one is that if we are to improve rational understanding, we should study some basic knowledge in management science that is related and should relate some advanced foreign and domestic management experiences. We should enrich and renew management concepts, and should spur on our own confidence and determination in realizing science management with a spirit of reform; in another sense, we should improve perceptual knowledge and should review empirical lessons on both sides of issues in normal management work. We especially should use particular results to analyze and compare, should publicize and educate the leaders at all levels and the vast numbers of researchers, should enhance the concept of rule by law, and should open up new aspects.

- 2. We should make management responsible, and should not have too many ins and outs.

We are just entering a technical society that is increasingly complex and of even higher levels. If we are to accomplish our development mission for large scale armament systems, we must rely upon the management principles for system projects. To this end, the work of management must also stress systems

management. Because at present work within guiding departments and working departments is not coordinated toward the greatest effects from management, it is our belief that:

a. Government organizations at all levels should meet the current needs for reform of the system, should focus on solving some problems in theoretical understanding and management policy that have been a source of contention for some years. Management rules and regulations that are promulgated should be revised and completed in a timely manner, and should pay special attention to lateral coordination between the various responsible departments.

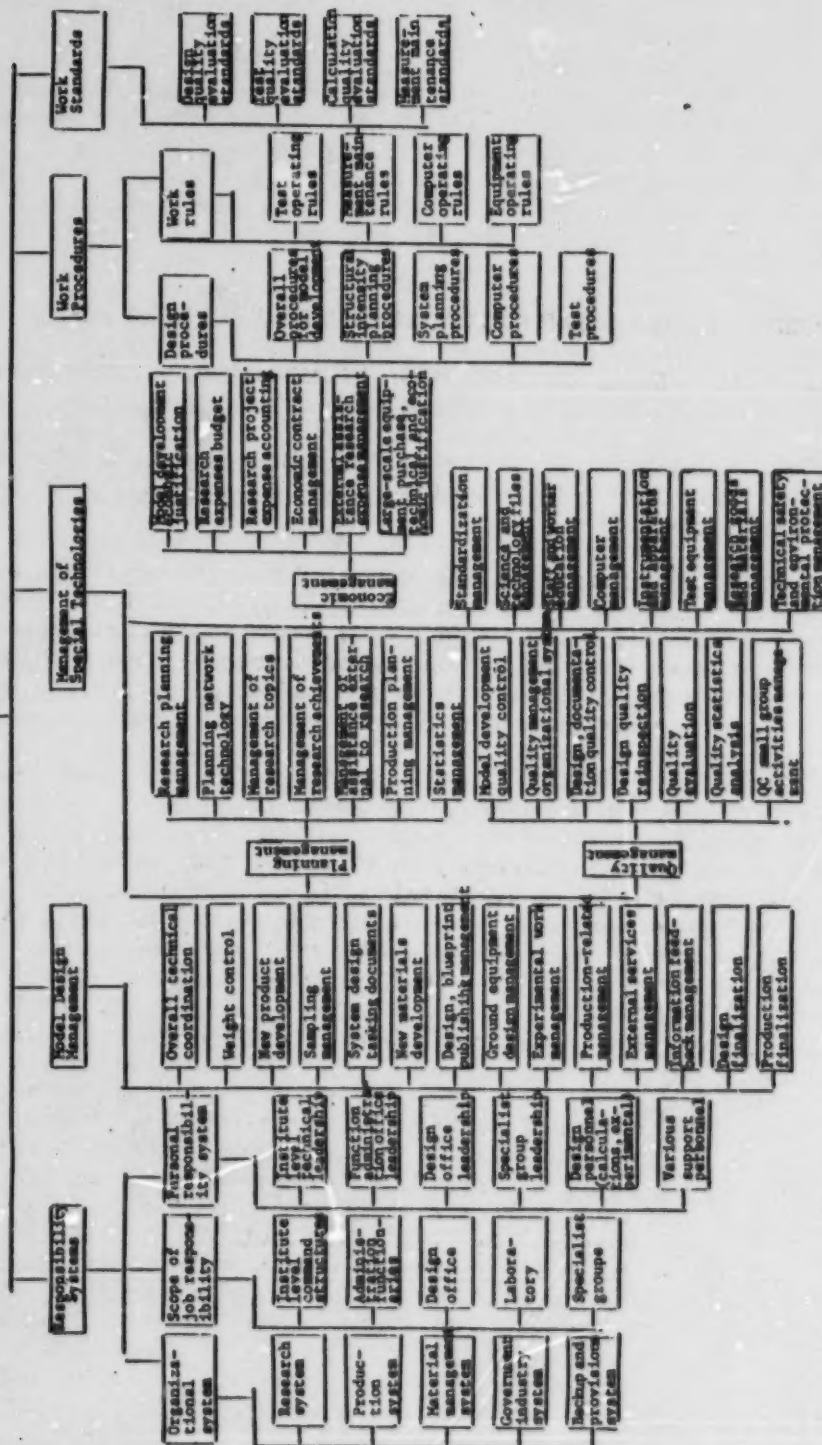
b. Management standards are like technical standards in that there is hierarchical management. Topics that are worked out should form a series table, with a planned, organized implementation.

c. Each enterprise should establish responsible management units according to specialty systems, they should carry out unified centralized management principles, sequentially develop in keeping with the requirements of goal management, and should clarify the responsibility system and relations between divisions of labor.

3. Management goals should be quantified.

Quantification is an important characteristic of science management. People see management work as a kind of "expendable" tasking, one reason for which is that there are many requirements in setting management goals, while quantity indexes are few, which does not make specific checking and testing easy. Add to this the fact that the majority of research work is creative mental effort, quantification is difficult, there are great gaps between specialties, and quantities of work are uneven. All of these problems are topics of study with which management science is faced. For this reason, research management personnel must get to the bottom of facts, should always operate under management rules, and should make management goals quantified as much as possible, and allow management to become a rigid index. This is the direction and path by which to improve management efficiency and to put a new face on management.

System Categories for a
Science Research Management System



NATIONAL DEVELOPMENTS

MANAGEMENT THEORIES DETAILED FOR INSTITUTES UNDERGOING REFORM

Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 2, Apr 86
pp 47-50, 40

[Article by Liu Fohua [0491 0154 5478], Ministry of the Electronic Industry
Institute No 29: "Some Problems As the Military Industrial Research
Institutes 'Change'"]

[Text] The resolution by the Central Committee regarding a reform of the science and technology system clearly pointed out that the direction and tasking of the reform of national defense research organizations would be in realizing several "changes." This paper discusses some problems in effecting those "changes." Although there are undoubted errors in this paper, the intention is to break ground so that others may continue and urge on the reform.

I. The Basic Concept Regarding "Change"

The basic situation currently in effect in the national defense research management system is: 1. Tasking is determined by the state, and the operating expenses of science research administrations are allocated by the state. 2. There is only research into military goods, not those for civilian use; military research achievements cannot quickly nor very effectively become civilian. 3. There is no consideration of completing directive planning, no concern about extending operations, no interest in economic results. 4. Control from the top is stifling, and there is no autonomy for the institutes. In this way, the research institutes have formed research institutes that are "pure military industrial models," "pure research models," and "closed models" (collectively called the "old three models"). Abuses in this kind of management system lie in the fact that the institutes eat from the state's "communal pot," the staff eats from the state's "communal pot," everyone's hands are holding "iron rice bowls," and there is no concern that there may not be anything in the pot to eat. For this reason, there is no pressure, motivation, or vitality in the research institutes. Actual practice has shown constantly that they no longer meet the needs of the "four modernizations," and that they seriously obstruct realization of the strategic principle that "economic revitalization will depend upon science and technology, and science and technology must cater to economic construction."

In the spirit of the "Resolution by the Central Committee Regarding Reform of the Science and Technology System," reform of the national defense research organizations will result in "three changes," namely: allocation of research and administrative operating expenses by the state through the administration system will change to a compensated contract system (through signing of vertical and lateral contracts) and a science base fund; there will be a change from an exclusive military goods model to an integrated military-civilian model; there will be a change from a purely research model to a research-production operations model that caters to society, caters to economic construction, and that opens technology markets to become institutes of the three new models of "military-civilian integration," "research-production operations," and "open."

This is a fundamental change for the research management system. The "old three models" represent the backward management models of the 1950's, which centered on the fact that all work carried out instructions from above and that are characterized by "waiting, dependence, need, and reporting." By 'waiting' is meant waiting for higher authorities to issue directive planning, by 'dependence' is meant depending on the state for allocation of funds, by 'need' is meant that the higher authorities were needed to resolve problems and difficulties, and by 'report' is meant that when planning had not been accomplished there was reporting to explain the reasons and to adjust the planning. The "new three models" represent a model of modern science management that is characterized by enhanced operational decision making, energetic development of civilian goods, the opening of technology markets, an improvement in technical, economic, and social results, and achievement of a basic self-sufficiency in operating expenses, all under the premise of accomplishing vertical and lateral contract tasking for military goods.

II. Changing Concepts Is the Ideological Foundation for Realizing the "Three Changes"

To realize the "three changes," we must change old concepts, old habits, and old methods that are not suitable to them, foremost of which is changing concepts. When concepts have changed, habits and methods will change along with them. So, what should be changed and what concepts should be established?

1. The concept of time.

There is a proverb that goes: "Comparing an inch of light and an inch of gold, the inch of gold cannot buy the inch of light." This concisely elucidates the value of time. If when taking on an expansion of operations, development of technology markets, and getting involved in competition, if there is no concept of time, then these activities can never be successful. However, as it happens, our current concept of time is deficient. As our mountains of documents are excavated, the higher they grow. As our seas of meetings are filled in, the deeper they become. Talking acts as reporting, and repetitious wordiness keeps people from understanding the main points. Disputes over trifles and insignificant wrangling is still in evidence everywhere, there is no feeling of urgency about accomplishing anything, much valuable time has been lost, and time has become a worthless object.

2. The concept of results.

Because military industrial institutes have for a long time had funds guaranteed by the state, there is a provisions system way of thinking, and many people have a poor or even non-existent sense of results. Therefore, research does not take costs into consideration, money is spent extravagantly, there is serious evidence of waste, there are great expenditures, and there are many loopholes. With a concept of results, there is sure to be an enhancement of management, the conditions above would be largely reduced, and economic results are sure to be greatly improved.

3. The concept of efficiency.

The greatest problem in the entire economic system of this country (including the military industry institutes) is not one of quantity, but is one of quality and management efficiency. Many management personnel lack a concept of efficiency, they are slow about doing things, and they are not efficient. With a concept of efficiency, there would certainly be a streamlining of staff and administration, structures that did not need to be would not be, people who did not need to be employed would not be, and meetings that are not necessary would not be held. There would be decisions from discussions, and then implementation after decision. Those who cannot justify a bungling of affairs will be charged with responsibility.

4. The concept of marketplace.

The closure of military industry research institutes for so long has created a weak concept of the marketplace, and fundamental work on market analysis and prediction is also rather weak. We should be watching surveys and analyses of markets, becoming familiar with information and feedback, and should treat markets as the starting and touch points for technology development and development of civilian goods. This is the basis for doing a good job at developing operations.

5. The concept of competition.

With a concept of competition, motivation can be put into place, there will be forecasting and analysis of events, and we will be on top of each fundamental task involved in competition. In the competition for bidding on tasking for military goods and in competition for the development of civilian goods and the technology markets, the pace will be set by the strong.

6. The concept of service.

Maintaining a reputation is foremost. Everything should be in consideration of the customer. Excellent service should be provided, efforts should be made to be constantly opening up new technology markets and to expand areas of service, and more vertical and lateral contracts should be signed to lay the foundation for more economic results.

7. The concept of value.

We must get rid of the effects of the "leftist" influence under which it was held that "the more knowledge there is, the more reactionary it is" and that we should "not respect talent," and should establish concepts of information, talent, and the value of knowledge, which should then be implemented in policy.

8. The concept of strategy.

In the light of strategy, we should be good at the overall picture, and should highly respect operational policies. Having achieved a sense by which attention is paid to the task at hand, where the distant and near are brought together, and where we earnestly carry out and obtain results, this will allow for a long-lasting capacity for competition.

The eight concepts we have just discussed require a firm establishment in leadership at all levels, leadership whose own actions educate and influence all staff and workers.

III. The Keys to the "Three Changes" Are in Adjustment of Cadre Structures and the Development and Training of Talent

Comrade Mao Zedong once said that "After the political line has been determined, cadres are a decisive factor." Premier Zhao has pointed out that "if we are to turn enterprises into enterprises of open models and of operational models, the keys lie in reforming the personnel system of enterprises, in choosing and preparing talent, and in delegating authority. When these are under control, there will be big changes in one-half or in a full year." For these reasons, while holding fast to the line, principles, and policies from the 3d Plenum of the 11th CPC Central Committee, we will meet the demands of the "four modernizations," will reform intently, will continue to advance outstanding young and middle-aged persons to positions of leadership at all levels, so that cadre structures after consolidation will be rational. The resolution of the Central Committee regarding restructuring of the economic system has clearly indicated the mission of adjusting leading groups in the enterprises: it will employ factory directors (managers) who will be able to effectively organize and guide enterprise production and operations. We will be able to enhance greatly technical management within the enterprises and to promote technically advanced senior engineers, who will be able to thoroughly strengthen enterprise operations. Senior economists who can improve results will be able to strictly safeguard financial discipline, and by careful calculation and careful budgeting, senior accountants who can open up financial resources can keep to a correct political direction. And there will be party secretaries who can unite the many staff and workers throughout the enterprises. Although in terms of management research institutes differ from enterprises, in wanting to change toward the direction of "research and production operational development models," we will need to select cadres in accordance with the cadre structures of the enterprises. Based on the current situation, we ought especially to require that institute directors have the guidance capacity for research and production and for decision making in autonomous operations, that they have the capacity for

making research institutes shift in the direction of openness and modern management. We also want talent in the areas of accounting or economics to assist institute directors in controlling operational management, carefully calculating and budgeting, opening financial resources, and improving results.

Economic invigoration will depend upon science and technology, and the invigoration and development of the institutes will be just the same. But science and technology does not descend from Heaven, but rather is controlled by people. Therefore, in the final analysis all depends upon whether or not there is talent. For example, during the last half of 1984 we undertook development of digital instantaneous goniometer (DBD) equipment. This equipment is characterized by a broad bandwidth, quick determination of direction, and high precision, but is very difficult. The key technology is the Butler transmission network. Engineers and technicians responsible for this task integrated the characteristics of the technology and techniques of the institute in question on the basis of foreign technical materials on DBD. They courageously undertook a major design simplification of the Butler network in the DBD and made a significant breakthrough. In only 5 months time they had successfully developed digital instantaneous goniometric equipment with Chinese characteristics. After technical appraisal by higher level organizations, it was held that this equipment fit the design requirements in every aspect, filled a domestic void in this area, and achieved standards equivalent to similar foreign products of the early 1980's. This serves to show that without talent there cannot be this high standard and high speed. Therefore, not only do we want to encourage the positive function and potential of existing talent, but we want also to pay close attention to the training of college students and vocational school students who graduate and are employed each year. We want to develop and train talent through every channel (for example, television courses, short term training, and encouraging self study) so that there will be those who follow. We not only want science and technology talent in large numbers, but also talent that is of high quality and able to manage operations.

There is no question but that with reasonable cadre structures and various kinds of talent, we will be able to overcome the difficulties in our path, will victoriously accomplish the reform, and will realize the task of the "three changes."

IV. Changes in Organization Management Structures Are the Organizational Basis for Realizing the "Three Changes"

Former organizational management structures have been determined by science and technology management systems from the past, and they are already unsuited to the needs of science and technology system reform. We must reform and establish organization management structures complementary to realizing the "three changes." This reform should respect the following principles.

1. It should benefit thorough implementation of the principle of "preserving the military while shifting toward the civilian, and integrating the military and civilian." Under the premise of safeguarding completion of military industry research and production tasking, it must strongly develop civilian goods and technology markets.

2. It should achieve the goals of streamlining, unification, and efficacy, effectively guaranteeing the command authority of the institute director for decision making, that decision making is quick, and that direction is effective. To this end, organizations must streamline and personnel must be capable; organizations should be systematic, there should be hierarchies for decision making, management, and execution, divisions of labor should be clear, and responsibilities apparent; organizations must be in matrix form, where the institute director carries out a vertical leadership of functioning departments through the deputy director, the senior engineers, and the senior accountants; it is best to provide for a deputy director of planning and operations to assist the institute director in operations management, and to enhance lateral coordination.

3. Enhance management organizations that control research and production costs and other management expenses. The goal is for strict control of expenditures, for better budgeting of project funds, for doing a statistical analysis of all investment benefits, for timely provision of materials to leaders, and to achieve low costs, low expenditures, and high results.

4. Strengthen the operations management structures for the development of technology markets. Detail comrades to these structures who know how to operate and can open things up, so that there will be a new aspect as quickly as possible.

5. Strengthen democratic management among staff and workers. Through this step, there will be a constant stimulation for staff and workers to have a feeling of responsibility for their own lives.

V. The Central Link To Realizing the "Three Changes" Is a Strong Focus on Management

For fundamental building toward an emphasis on management, by gathering and doing statistical work on various data, there can then be a comparative, analytical, and scientific review of experiences, and a search for rules and laws that will allow management to continually improve and intensify. Below, we discuss some of the major management work.

1. Planning management.

This has the leading position in all of management work, where each management task is concerned with planning and develops from it. The key to planning management is first of all to investigate and clarify conditions relevant to the drafting and formulation of plans in order to carry out planning forecasting. And it is in the rather scientific, comprehensive, and even final draft, the production of the networking flowcharts, after which organizational implementation and coordination and the solving of problems that arise during implementation will allow things to run efficiently. It is necessary to choose comrades of high quality and abundant experience to be responsible for planning management. It is necessary for all relevant personnel to obey the directions of planning management personnel, and to accomplish missions as much as possible according to networking flowcharts; it is necessary that planning management personnel gather their energies to

accomplish planning management, to study the problems therein, to constantly review and improve, and to become effective managers who are proficient in their professional work.

2. Technology management.

This is an important guarantee for realizing planning management, and is the basis for obtaining technical and economic results. On the one hand, pay close attention to technology development planning, including it in the annual implementation of planning; second, pay close attention to the regular technical management of each research trial production project, as for example: pay close attention to the implementation and execution of sequences in research, program verification, special studies, and key problems in technology and technical appraisals, in an attempt to avoid a great deal of repetition. To do a good job of technical management, not only must relevant personnel in technical commands (as for example, full and assistant senior engineers, directors of laboratories, and technology management departments) take direct responsibility, but technical personnel who take on research tasking projects must also be duty-bound. Diligent implementation of research work schedules is the key to avoiding major problems in daily technology management, and managers must work strictly in accordance with the stages outlined by the schedules and be strict about checks. After meeting the needs of primary goals, the next stage can be entered. To reach a stage without confusion or excess development will also accomplish stage transitions in a timely manner.

3. Quality management.

Without quality, there is no quantity and planning progress, nor are there customers and results, and there can even be a loss of reputation. Seek invigoration through technology, seek existence through quality, and since it is the same for industrial enterprises, how could institutes be any exception in the future. For this reason, we must have quality control to guarantee quality.

4. Management of standardization.

This is a fundamental task for technology that should be actively disseminated and applied. When there is a high degree of standardization, this has a great affect on speeding up the progress of research and production planning, on improving quality, on lowering expenditures, and on improving economic results.

5. Management of material goods.

This has a direct affect on the two important problems of completion of research and production planning and the extent of technical and economic results. Aside from timely provision of the material goods needed by research and production, there must also be a strengthening of management, implementation of cost controls, prohibition of waste, and a filling in of loopholes. For the latter, the following measures may be adopted: first, implement a system that relies upon coupons for redemption. The coupon will

provide for a limited outlay, so first determine the amount of annual outlay for a project, then divide that up according to the total, for each machine, and for each component, and give them to the persons in charge of that task. The amount of outlay will be written clearly on the coupon. Application is necessary before it can be redeemed for an amount in excess of the limit, and the planning department must agree after investigation before additional outlay may be added. Otherwise, those in charge of the warehouses have the authority to refuse redemption. This can both guard against the occurrence of the phenomenon of someone taking another's place and also aids in accounting; second, implement a system with limited allocation of materials, with rewards for economy. For example, restricted standards for issuance of provisions can be formulated for research goods and materials according to the three different categories of basic research, model advanced development, and production projects, or based on different components or raw materials, or according to different proportions. Savings within the restricted range will be rewarded (determining a reasonable proportion for rewards), with no reward and an investigation if the limit is exceeded. And it can also be based on the rate of use on the machine in accordance with the three different items just mentioned (the ratio of that used on the machine to the actual number redeemed). There will be rewards for a certain percentage over the quantity actually used, with an investigation and no reward if the savings is less than the actual use rate. This method will generate a positive effect, the key being to determine the standard limiting the use of materials. The difficulty here and amount of work is rather great, but after diligent practice, attention to statistical analysis, a review of experiences, and with increasing perfection, reasonable standards for limits can certainly be drawn up.

6. Financial management.

The focus here is in careful financial supervision, safeguarding financial discipline, doing a good job at budgeting for project expenses, and analysis of technical and economic results, as well as investment management and results analysis in other areas. Actively comply with measures and methods proposed by relevant departments to improve technical and economic results, which should be implemented after approval by the institute director.

VI. To Promote Goal Management and Establish a Technical and Economic Responsibility System that Integrates Responsibility, Authority, and Profit with Responsibility At Its Core Is To Implement the Important Measures of the "Three Changes"

So called "goal management" is just a management process that sets up methods by which to arrange work, making it easier to realize a specified goal (or condition) within a specified time. It is a method by which to organize institute activities, and is also a method for planning and controlling actual achievements. How military industry institutes are to undertake goal management is a new topic, on which I offer some superficial ideas and methods below.

1. Determine goals.

In practicing goal management, the first thing to do is to determine goals, in which are included the following matters: 1. research and production operations development planning; 2. the quantities and technical standards of scientific and technical achievements, and requirements for dissemination and application; 3. economic results and per capita income; 4. within the allowable limits of national policy, the goal of perfecting and improving material and cultural living standards for staff and workers. Generally speaking, it is best to draw up the objectives for a total of 3 (or 5) years. Under overall goals, also draw up the objectives for each year.

2. Take care of internal contracts.

Fully motivate the enthusiasm of all personnel through the use of contracts, the methods for which are: 1. divide up each year's objectives, clarify quotas, and implement hierarchical contracts. The contractual method is determined according to actual conditions in the particular institute, as for example, undertaking vertical (topic) contracts or lateral (with laboratory or workshop as the unit) contracts, or a method by which vertical and lateral contracts are integrated, after which topics or units contract with individuals; 2. set up and complete technical and economic responsibility systems within the contracts, and expand the authority of contractors (units) to aid completion of contract responsibilities; 3. because completion of contract responsibilities requires guarantees from relevant departments, a warranty system should be established that is integrated with contract responsibilities, so that the circle is complete; 4. strict check-ups, make good on rewards and punishments. There should be specific accounting methods, rewards and punishments should be closely tied to amount of responsibility, degree of tasking, degree of difficulty, technical standards, nature of quality, and degree of efficiency, and the files should be open. There should be no accommodation or taking care of friends, and even less should persons in charge be relatives or parts of cliques.

To urge the development of the contract system, no rewards should be allowed for those who have not contracted for responsibility; for those who have not contracted for responsibility over a long period, basic wages should be reduced (with consideration for length of service); if this involves personnel in a contract system, they should leave their job after fulfillment of the contract period. It should be pointed out that this is work that is extremely policy oriented and may not be ignored. When a contract responsibility cannot be met due to illness because of overwork or weakness due to age, it will be appropriate to either reduce or not the basic wage.

3. Problems that should be noted.

The goals that are determined should be greater than actual capabilities so as to arouse enthusiasm, but they must be such that they can be achieved through effort. This makes an even greater demand upon planning management and those involved in that work. The goals of each unit, each topic, and each individual should be extremely clear. There can be no misunderstandings, for otherwise goal management cannot be smoothly carried out. Technical

developments change all the time, and the goals that are determined should keep up with changes. Appropriate adjustments are permitted, but these may not be blindly done. Each managing department should be strict in checking on things, and should as well help lower levels and individuals to realize their goals, and complete their contract responsibilities.

12586

CSO: 4008/68

NATIONAL DEVELOPMENTS

BRIEFS

CONFERENCE ON TECHNOLOGY MARKETS--To better implement the "Resolution by the CPC Central Committee Regarding Restructuring of the Science and Technology System," and to promote the healthy development of technology markets, with the permission of the State Council the National Technology Market Coordinating Leading Small Group resolved to convene a national technology market working conference in Beijing from 14-18 March. This conference has been called as technology markets are springing up abruptly throughout the country, and is the first large meeting on a national scale since we opened up the technology markets. More than 300 representatives from all ministries and commissions of the State Council, leaders from all provinces, municipalities, and autonomous regions, and from various sectors of science and technology, economics, planning, education, finance, banking, tax revenue, personnel, and legislation will participate in the conference. Carrying out the principles of "relaxing controls, invigoration, support, and guidance," the conference will review and exchange the experiences of various regions and sectors regarding the opening of technology markets; it will further study the problems that need resolution regarding the promotion of healthy development of the technology markets; it will discuss and formulate relevant rules for the technology markets, all in order to continue developing a new look for the technology markets. [Text] [Tianjin JISHU SHICHANG BAO in Chinese 11 Mar 86 p 1] 12586

CSO: 4008/2099

APPLIED SCIENCES

SIMULATION STUDY OF COMBUSTION MECHANISM OF ALUMINUM IN SOLID ROCKET PROPELLANT AT HIGH TEMPERATURES AND PRESSURES IN A SHOCK TUBE

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 6, No 3, Aug 85 pp 284-286

[Article by Liu Zichao [0491 1311 6389]]

[Text] I. Introduction

The study of aluminum combustion in pure oxygen or in a $N_2-H_2-Cl_2-O_2$ gas mixture under high temperatures and high pressures (as high as $5000^\circ K$ and 40 atmospheres) in a shock tube can provide simulated conditions for studying the combustion mechanism of aluminum in solid rocket propellant. In this study, calculations of equilibrium constituents under different combustion conditions are carried out to predict possible intermediate and final products of combustion. The emission spectra of certain important intermediate products are identified using a spectrometer and time histories of the AlO emission band are recorded. Detection of the continuous spectrum of Al_2O_2 indicates that AlO is a precursor to Al_2O_2 in the reaction process. The solid and liquid products as well as condensed particles are observed and analyzed using electron diffraction, x-ray diffraction, transmission techniques and scanning electron microscopes. Gaseous products are analyzed using infrared spectrometry. The measurements are in good agreement with computed results and provide useful chemical kinetic data.

It is known that the performance of solid rocket propellant can be significantly improved by adding aluminum. Over the years, many studies have been conducted on this subject, but the problem of chemical kinetics is not well understood. Most studies of aluminum-oxygen reactions have been conducted below 10 atmospheres; essentially no data exists above 10 atmospheres, neither are there any data on aluminum reactions in ammonia perchlorate. As a consequence, predicting the performance of rocket engines is very difficult. For example, because the condensation mechanism of Al_2O_2 particles is still not well understood, it is difficult to predict the effect of the resulting two-phase flow.

The high-temperature, high-pressure region behind a reflected shock wave in a chemical shock tube can simulate the conditions in a rocket engine. Fig. 1 shows the schematic diagram of the aluminum reaction region behind the reflected shock wave in a shock tube. The combustion process and the emission

spectra of intermediate products are recorded using high-speed cameras and spectrometers. The experimental results show that aluminum ignites when the temperature T_5 is between 2000°K and 2400°K , and emits the blue-green light of AlO . This ignition temperature correlates with the melting point of 2300°K of the oxidized layer. By carrying out calculations of the chemical equilibrium constituents, it is possible to predict the intermediate and final products of an Al-O_2 or an $\text{Al-N}_2\text{-H}_2\text{-Cl}_2\text{-O}_2$ reaction and use it as a guide for the experiment. The intermediate and final products can be analyzed using spectral techniques, electron and x-ray diffraction techniques, electron microscopes and infrared spectrometry techniques. The results provide useful chemical kinetic data.

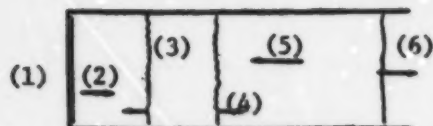


Fig. 1. Schematic Diagram Showing Reaction Region in Vicinity of Aluminum Behind Reflected Shock Wave

Key:	1. aluminum foil	4. final products
	2. aluminum vapor	5. working gas
	3. intermediate products	6. reflected shock wave

II. Calculated Results of Intermediate and Final Products From Aluminum Combustion

First, the state of the working gas before combustion (pure oxygen or a mixture of $0.1\text{N}_2+0.4\text{H}_2+0.1\text{Cl}_2+0.4\text{O}_2$) is calculated. Then the intermediate and final products of aluminum combustion under such high temperature and high pressure conditions are calculated. The calculation is based on the method of minimizing the Gibbs free energy under constant pressure and constant enthalpy; it also takes into account real gas effects.

For the Al-O_2 reaction, calculations show that when the Mach number of the incident shock wave is $M_9=9.1$, the state of oxygen before ignition is: $P_9=28.9$ atmospheres, $T_9=4418^\circ\text{K}$, and the composition is: 43 percent of mol fraction oxygen atoms and 56 percent oxygen molecules. The weight ratio between oxygen and aluminum is 1.32, and the aluminum is preheated to a temperature of 900°K . The calculation takes into consideration the possible formation of 23 different constituents during combustion. The temperature after combustion is 4930°K . The intermediate products with the largest proportions are: O (42%) and AlO (19.7%); other products include: Al , Al^+ , AlO^+ , AlO^- , Al_2O , AlO_2 , Al_2O_2 , Al_2O_3 , and O^- .

For the $\text{Al}-(0.1\text{N}_2+0.4\text{H}_2+0.1\text{Cl}_2+0.4\text{O}_2)$ reaction, the weight ratio between the gas mixture and aluminum is 2.6, and the composition, the ratio of specific heats, and molecular weight of the gas mixture before combustion are calculated for different values of M_s , T_5 and P_5 . The maximum Mach number, temperature and pressure of the experiment are $M_s=10.5$, $T_5=5150^\circ\text{K}$, $P_5=40$ atmospheres. Under the typical condition of $M_s=7.8$, $T_5=4149^\circ\text{K}$, and $P_5=14.3$ atmospheres, the main constituents before combustion are: O (17%), OH (14.3%), H (13.4%), O_2 (11.4%), H_2O (10.4%), Cl (9.8%), HCl (7%), plus N_2 , H_2 , and NO. The combustion process may produce 80 different constituents; Fig. 2 shows the calculated results of 23 constituents. The constituents with the largest proportions are: Al, AlO, AlCl, HCl, H, O, OH, and Cl. The molecular weight of the combustible gas is 25.67 gm/mol, and its ratio of specific heats is 1.118. Fig. 3 shows the changes of 18 intermediate products during the cooling process. The final products are primarily water, water vapor, HCl, ammonia, N_2 and H_2 as well as Al_2O_3 . This result is in agreement with the measured results of rocket experiments.

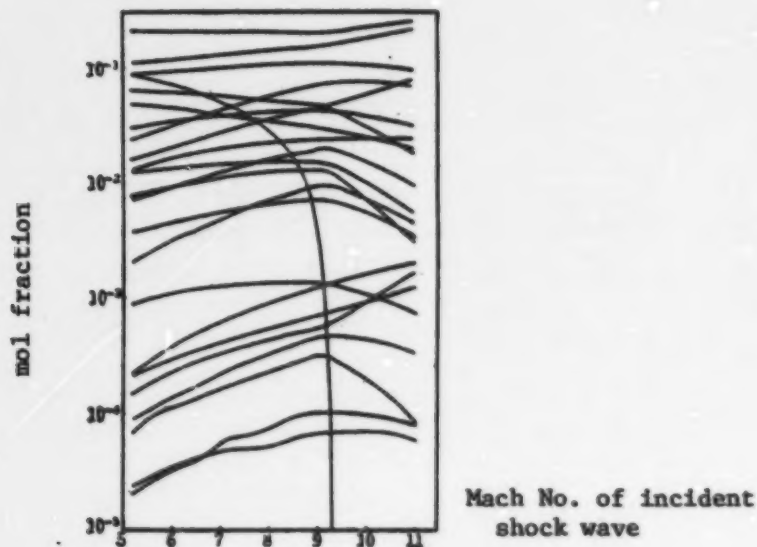


Fig. 2. Calculated Results of the Constituents in an Aluminum-Gas Mixture Reaction. From upper left to right, they are respectively: H, O, OH, Al_2O_3 , H_2O , HCl, AlCl, AlO, Al, NO, AlOCl, AlO_2H , AlO_2 , AlOH, Al_2O , AlCl₂, AlH, Al^+ , N, AlO^- , Al_2O_2 , HAIO, AlOH^+ .

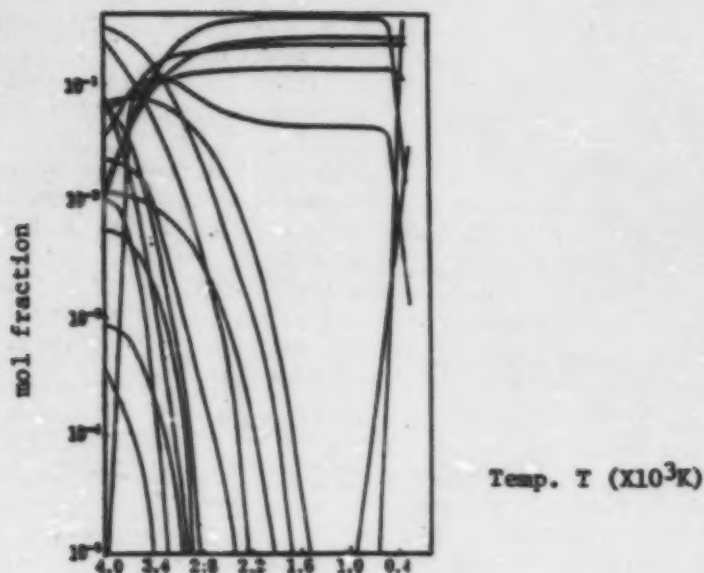


Fig. 3. Changes of the Constituents During the Cooling Process after an Aluminum-Gas Mixture Reaction. From left to right, they are respectively: H, O, Al, Cl, AlOH, N₂, H₂, AlCl₂, HCl, NO, H₂O (vapor), Al₂O, AlO₂, Al₂O₂, AlH, Al₂O₃ (liquid, solid), H₂O (liquid), NH₃.

III. Measured Data of Intermediate and Final Products of Aluminum Combustion

The Al spectral line (3944, 3961.5 Å), the Al⁺ line (5861 Å) and the 6 bands of AlO (4373, 4470.5, 4648.2, 4842.3, 5059.3, 5226.9 Å) have been recorded using a spectrometer. Within the visible-light region, no spectral band of AlO₂, Al₂O or Al₂O₂ is detected, but the AlO band is very pronounced. In the Al-N₂-H₂-Cl₂-O₂ reaction, large numbers of overlapping spectral lines and bands are emitted, but the spectra of Al, Al⁺, AlO, AlH, H and O can still be identified. The weaker bands probably correspond to AlCl, AlCl₂, and AlOH. The time history of the AlO band (see Fig. 4) shows that the peak intensity occurs at 1.4 msec after ignition, and it attenuates after 2 msec; this is followed by a strong continuous spectrum which lasts for 14 msec. Analysis shows that this is part of the Al₂O₂ reaction, and that AlO may well be a precursor to Al₂O₂.

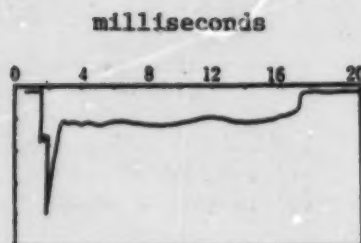


Fig. 4. History of the 4846.2 Å Spectral Intensity of AlO

The white powder produced by the Al-O₂ reaction has been identified to be Al₂O₃ using x-ray diffraction techniques. The spherical particles as measured by the electron microscope range in size from 0.1 to 0.6 microns, which are consistent with the sizes of Al₂O₃ particles in the exhaust plume of rockets. The solid products from the Aluminum-gas mixture reaction have been identified to be condensed Al₂O₃ particulates suspended in a liquid of HCl+H₂O; they are no longer spherical. It is evident that particle condensation is a result of reactions with HCl and H₂O.

The gaseous products from the aluminum-gas mixture reaction have been identified using infrared spectrometry to be water vapor and HCl vapor, which is in agreement with calculations. The large amount of measured NO and NO₂ which greatly exceed the calculated amount is caused by the non-equilibrium cooling process.

IV. Conclusion

1. The region behind a reflected shock wave in a chemical reaction shock tube can provide simulated conditions for studying the combustion mechanism of aluminum in solid rocket engines.
2. The calculated intermediate and final products after combustion are basically in agreement with measured results. This provides useful data for studying the combustion mechanism of aluminum under high temperature and high pressure conditions.

3012/12859
CSO: 4008/59

STUDIES OF THE COLOR REACTION OF QUATERNARY COMPLEX ALUMINUM-FLUORINE-XYLENOL ORANGE-CETYLPIRIDINE BROMIDE

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 12,
20 Dec 85 pp 881-886

[English abstract of article by Ren Ying [0117 5391], et al., of Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Text] In neutral solution a quaternary complex of aluminum can be formed in red with NaF, xylenol orange (XO) and cetylpyridine bromide. This complex exhibits maximum absorption at 520 nm with an apparent molar absorption coefficient of 1.6×10^4 . This complex is so stable that a large amount of DTPA does not interfere with the determination of Al. In the presence of DTPA there is no interference by large amounts of Fe^{3+} and a number of other diverse ions. Therefore, a method is developed for determining aluminum in nickel-chromium-iron alloy, zinc-cast aluminum alloy and copper-cast aluminum alloy with satisfactory results. The procedure is simple and rapid. (Paper received 6 September 1984.

REFERENCES

- (1) В.Н.Тихонов, Л.Ф.Петрова, *Зсс.Лаб.*, 39(6), 672(1973).
- (2) 云大泰, 理化检验 (化学分册), 19(5), 5(1983).

APPLICATION OF PC-1500 COMPUTER TO IMPROVED STANDARD ADDITION METHOD

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 12,
20 Dec 85 pp 903-908

[English abstract of article by Li Yuxiu [2621 3768 4423], et al., of the
Department of Chemistry, Nankai University]

[Text] A description is given of a procedure for the preparation of a perchlorate-coated electrode, the determination of perchlorate ion concentration by an improved standard addition method and the calculations on a PC-1500 computer. The authors have calculated $C_{ClO_4^-}$ at $C_{ClO_4^-} = 1.0 \times 10^{-4}M$, and $C_{ClO_3^-} = 1.0 \times 10^{-2}M$ on a PC-1500 computer and obtained a mean result of $C_{ClO_4^-} = 1.08 \times 10^{-4}M$. (Paper received 17 December 1984.)

REFERENCES

- [1] 松下宽, 石川德久, 岡田勝, 日化, 5, 775 (1982).
- [2] Charles R. Martin and Henry Freiser *J. Chem. Educ.*, 57 (7), 512 (1980).
- [3] 华罗庚, 高等数学引论, 第一卷, 第一册, 第85页, 科学教育出版社, 北京, 1962.
- [4] 丁士晟, 多元分析方法及其应用, 吉林人民出版社, 长春, 1981.
- [5] K. Srinivasan, and G.A. Rechnitz, *Anal. Chem.*, 41, 1203 (1969).

DETERMINATION OF MICROAMOUNTS OF VANADIUM (V) IN ORES

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 12,
20 Dec 85 pp 928-930

[English abstract of article by Duan Qunzhang [3008 5028 4545], et al., of
the Department of Chemistry, Southcentral University of Technology]

[Text] In the buffer solution of $\text{CH}_2\text{ClCOOH-NaAc}$ at pH of 2.0-3.0, V(V) reacts with 5-Br-PADAP to form a 1:1 complex, which can be dissolved by a surfactant and has maximum absorption at 590 nm. Its molar absorptivity is $9.06 \times 10^4 \text{ l}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$. Beer's law is obeyed in the range of 0.2 to 16 $\mu\text{g}/25 \text{ ml}$ of V. This method has been applied satisfactorily for the determination of microamounts of V(V) in ores. (Paper received 6 August 1984.)

REFERENCES

- [1] 沈乃英等, 理化检验, (4), 2 (1983).
- [2] 刘绍理, 理化检验, (2), 24 (1981).
- [3] 郑用照等, 化学试剂, (2), 73 (1982).

9717

CSO: 4009/1049

STUDY OF THE PERFORMANCE AND MECHANISM FOR POLYACRYLAMIDE OXIME-CARBOXYLIC
ACID CHELATE FIBER ENRICHING VARIETY OF TRACE ELEMENTS

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 14 No 1,
20 Jan 86 pp 1-8

[English abstract of article by Chang Xijun [1603 1585 0193], et al., of the
Chemistry Department, Lanzhou University]

[Text] The polyacrylamide oxime-carboxylic acid chelate fiber was synthesized using polyacrylonitrile fiber as the original material. The conditions for acidity of quantitative enrichment, adsorption rate, desorption acidity, saturated adsorption amount and interfering coexisting ions on 30 kinds of trace elements were investigated. The stability, acid-base tolerance and generative performance of the chelate fiber and enrichment mechanism are discussed. The enrichment of lower concentration as well as the determination of samples have been achieved with satisfactory results. (Paper received 6 August 1984; finalized 6 May 1985.)

REFERENCES

- [1] 小林力夫、西末雄, 化学工业 (日), 23, 93 (1972).
- [2] 俞德清、刘桂琴, 环境科学学报, 1 (2), 180 (1981).
- [3] 罗兴寅、詹光耀、常希俊等, 兰州大学学报, 19 (化学辑刊), 101 (1983).
- [4] Yu Xiangzhang et al., *Mikrochim. Acta*, 291 (1984).
- [5] Doina Bilba and Simon Fisel, *Mikrochim. Acta*, (6), 985 (1974).
- [6] 黑田六郎、小藤幸一、铃木信、府中裕一, 分析化学 (日), 24, 1 (1975).
- [7] YaYoi-Cho.Chiba [Japan], *Talanta*, 24, 163 (1977).
- [8] K. Hayakawa and H. Yamakita, *J. Appl. Polym. Sci.*, 21, 685 (1977).
- [9] 罗兴寅、常希俊、苏敦兴、詹光耀等, 分析实验室, 3, 52 (1984).
- [10] 苏敦兴、罗兴寅、常希俊等, 合成纤维工业, 6, 22 (1984).

MICRO-DETERMINATION OF YTTERBIUM WITH ELECTROTHERMAL ATOMIC ABSORPTION SPECTROMETRY

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 14 No 1, 20 Jan 86 pp 8-12

[English abstract of article by Chen Depu [7115 1795 2613], et al., of the Institute of Chemistry, Chinese Academy of Sciences]

[Text] This communication reports the use of a pyrolytic graphite coated tube, lined with tantalum-tungsten, and a locally-made atomic absorption spectrometer (Model WFD-Y3) for the determination of trace amounts of Yb in pure Y_2O_3 and mixed rare earth oxides. It is found that the method proposed is sensitive, reproducible and simple to manipulate. Even as low as $0.2 \mu g$ Yb in a one-gram sample ($n \times 10^{-7}$) can be determined directly without pre-concentration. It is found experimentally that the optimum condition for drying is at $150^\circ C$ for 20 sec, ashing at $1000^\circ C$ for 20 sec and atomization at $2770^\circ C$ for 12 sec. Within the range of 1.0-18 ng Yb/ml, the calibration curve of Yb is linear. Before injecting it into the tube, the acidity of the sample solution should be adjusted to 0.1 to 2 M with nitric or hydrochloric acid. For 5 ng Yb/ml, Al(III), Ca(II) and La(III) interfere when their amount present is 50 $\mu g/ml$ or more. On the other hand, Cu(II), Fe(III), Mg(II), K(I) and Y(III) in amounts of up to 1 mg/ml do not interfere. (Paper received 4 July 1984; finalized 8 June 1985.)

REFERENCES

- [1] 藤野 治, 松井正和, 分析化学 (日), 31 (5), 241 (1982).
- [2] B.B.Лянов, Л.А.Паньина, Зее.Лаб., 44 (2), 173 (1978).
- [3] B.V.L'vov and L.A.Pelieva, Can. J. Spectrosc., 23 (1), 1 (1978).
- [4] 吴正科, 马怡敏, 环境化学, 1 (3), 228 (1982).
- [5] P.N.Walsh, H.W.Goldstein and D.White, J. Am. Ceram. Soc., 43 (5), 229 (1960).
- [6] Gmelin Handbuch der Anorganischen Chemie, 8. Auflage, Teil C1, S.161, Springer-Verlag, Berlin, Heidelberg, 1974.
- [7] B.B.Лянов, Л.А.Паньина, ЖХХ, 34 (9), 1744 (1979).

SIMULTANEOUS SPECTROPHOTOMETRIC DETERMINATION OF TRACE SILICON, PHOSPHORUS AND ARSENIC AS CRYSTAL VIOLET-HETEROPOLY ACIDS IN THE PRESENCE OF NONIONIC SURFACTANT

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 14 No 1, 20 Jan 86 pp 15-21, 46

[English abstract of article by Wang Zhendi [3769 6966 2769] of the Center of Chemical Analysis, Nanjing Institute of Forestry; and Zheng Yongxi [6774 3938 3556] of the Department of Chemistry and Chemical Engineering, Qinghua University]

[Text] A highly sensitive and convenient spectrophotometric method is described for simultaneous determination of Si, P and As, based on the ion-associates formed by heteropoly acids with crystal violet (CV) in the presence of the emulsifying agent OP. The optimum conditions are as follows: $[H^+] = 0.26 N$, $[MoO_4^{2-}] = 1.5 \times 10^{-3} M$, $[CV] = 1.2 \times 10^{-4} M$ and $[OP] = 3.1 \times 10^{-3} M$. The maximum absorbance of the ion-associates (CV-SiMo, CV-PMo, CV-AsMo) is at 555 nm, and the absorbance of the three ion-associates has additive properties. The molar absorptivities of CV-SiMo, CV-PMo and CV-AsMo are 1.45×10^5 , 1.70×10^5 and $1.69 \times 10^5 l \cdot mol^{-1} \cdot cm^{-1}$ at 555 nm respectively. The proposed method has been applied to the determination of trace amounts of Si, P and As in waters and alloys with satisfactory results. The dependence of the molar ratio of the main components in the ion-associates on the acidity is discussed further. It is found that the spectrophotometric properties and molar absorptivity of the ion-associates are mainly dependent on those of the basic dye cations. (Paper received 29 October 1984.)

REFERENCES

- [1] Z. Marczenko, «Spectrophotometric Determination of Elements», (1976). 郑用熙等译, «元素的分光光度测定», 地质出版社, 第20, 358, 406页, 1983.
- [2] A. Dyfverman et al., *Anal. Chim. Acta*, 23, 491 (1960).
- [3] J. A. Stobart, *Analyst*, 94, 1142 (1969).
- [4] A. K. Бабоко и др., *Ж А Х*, 24, 854 (1971).
- [5] Z. Marczenko and K. Kasiura, *Chem. Anal. (Warsaw)*, 9, 321 (1964).
- [6] A. K. Бабоко и др., *Ж А Х*, 21, 196 (1968).
- [7] A. K. Babko et al., *Chem. Anal. (Warsaw)*, 11, 1091 (1966).
- [8] 郑用熙, 王镇雄, 分析化学, 11 (8), 596 (1983).
- [9] 郑用熙, 王镇雄, 化学试剂, 8 (2), 70 (1983).
- [10] 王镇雄, 郑用熙, 中国化学会第二届全国多元络合物光度分析学术会议论文集, 山东济南, B26, 1984.9.
- [11] 郑用熙, 王镇雄, 高等学校化学学报, 8 (3), 327 (1984).
- [12] 郑用熙, 王镇雄, 化学学报, 42 (2), 156 (1984).

DETERMINATION OF IRON AND MANGANESE IN NATURAL WATERS BY THE 2.5 ORDER
DIFFERENTIAL POLAROGRAPHY

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 14 No 1,
20 Jan 86 pp 22-25

[English abstract of article by Lin Wenru [2651 2429 1172], et al., of the
Department of Chemistry, Fuzhou University]

[Text] A 2.5th differential polarographic method for determination of Fe
and Mn in tap water and thermal spring water has been developed. With a
solution of 0.001M $\text{KNaC}_4\text{H}_4\text{O}_6$ -0.01M NH_4Cl - NH_4OH (pH 5.5-7.0) as the supporting
electrolyte, Fe and Mn give well-defined neopolarograms. The amounts of Fe
and Mn are then determined by the standard addition method. It is found that
Ca(II), Cd(II), Co(II), Cr(III), Cu(II), Mg(II), Ni(II), Pb(II) and Zn(II)
do not interfere with the determination under experimental conditions.
(Paper received 19 December 1984.)

REFERENCES

- [1] M. Goto, T. Hirano and D. Ishii, *Bull. Chem. Soc. Jpn.*, **51**, 294 (1978).
- [2] 朱果逸、汪尔康, 1981年电分析化学学术会议论文集(上), 第2页, 1981.
- [3] 王耀光, 林文如等, 福州大学学报, (4), 70 (1982).
- [4] 殷福森, 理化检验, **20** (2), 16 (1984).

NEW GRAPHIC METHOD FOR DETERMINING THE COMPOSITION OF COMPLEXES AND FORMATION
CONSTANT BY SPECTROPHOTOMETRY

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 14 No 1,
20 Jan 86 pp 25-30

[English abstract of article by Li Changhua [2621 7022 5478], et al., of
Fujian Research Institute of Metallurgical Industry]

[Text] A new method for determining the real composition of complexes is presented. the method is based on the effect of dilution on the degree of dissociation, but the mathematical treatment is different from the others previously described. The formation constant is assumed to be the function of some independent variables, and an indeterminate equation is set up and solved by the graphic method to obtain the values of m and n for complexes of the type M_mB_n . The formation constant is given as well. The method is applicable to mixed ligand complexes and binary complexes. The results for three well-studied systems, Fe-chromazurol S, Cu-orotic acid and Ni-anthrapurpurin, are shown as the demonstrations. (Paper received 29 December 1984.)

REFERENCES

- [1] 何锡文, D.P.Poe, *Anal. Chim. Acta*, 100, 353 (1982).
- [2] 何锡文, D.P.Poe, *Talanta*, 20, 787 (1982).
- [3] 何锡文, 潘源士, 史慧明, 分析化学, 12, 29 (1984).
- [4] B.W.Buděšínský, *Z. Phys. Chem. (Frankfurt)*, 76, 310 (1971).
- [5] Idem, *Coll. Czech. Chem. Comm.*, 27, 226 (1962).
- [6] Idem, *Z. anal. Chem.*, 207, 178 (1965).
- [7] Idem, *J. Inorg. Nucl. Chem.*, 31, 1345 (1969).
- [8] Idem, *Z. anal. Chem.*, 200, 379 (1965).
- [9] D.V.G.Garcia et al., *Talanta*, 20, 315 (1979).
- [10] T.R.Galan et al., *ibid.*, 27, 545 (1980).
- [11] J.J.B.Nevado et al., *Anal. Chim. Acta*, 124, 301 (1981).
- [12] M.R.Cebal et al., *ibid.*, 100, 183 (1981).
- [13] K.S.Klausen and P.J.Langmeyer, *ibid.*, 20, 335 (1963).
- [14] 李长华, 分析化学, 待发表。

FACTOR ANALYSIS PHOTOMETRY FOR DETERMINING MULTICOMPONENTS OF MIXTURES

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 14 No 1,
20 Jan 86 pp 34-40

[English abstract of article by He Xiwen [0149 6932 2429], et al., of the
Department of Chemistry, Nankai University]

[Text] Factor analysis has been used as a powerful tool for determining the number of components that contribute to the absorption spectra of multi-component systems. The use of such an approach for both qualitative and quantitative analysis of mixtures is described. Rank analysis showed that there were three components present in the mixture (Ni, Cu, Zn). This technique was also applied to data concerning mixtures of four components (Ni, Cu, Zn, Co). We concluded that sample components were present since each component acted as a factor. The nine statistical criteria were employed to reach this conclusion. Each of these criteria requires an exact knowledge of the experimental error. Model data are used to illustrate the behavior of these functions. The method has been applied to problems of interest to chemists involving nuclear magnetic resonance, absorption spectroscopy, mass spectra, etc. (Paper received 30 January 1985.)

REFERENCES

- [1] P. Arnaud, R. Guihard, D. Cuihard, *Analysis*, 2, 294 (1973).
- [2] J.C. Sternberg et al., *Anal. Chem.*, 32 (1), 84 (1960).
- [3] 王保宁, 李占双, 化学学报, 41 (8), 700 (1983).
王保宁, 分析化学, 12 (3), 229 (1984).
- [4] 何锡文, 张大干, 分析化学, 7 (3), 179 (1979).
胡鑫尧等, 分析化学, 10 (7), 435 (1982).
- [5] M.F. Delaney, *Anal. Chem.*, 56, 261R (1984).
- [6] C.J. Appellof, E.R. Davidson, *Anal. Chim. Acta*, 140, 9 (1983).
- [7] J.T. Chen, A.M. Gardner, *Am. Lab.*, 15, 26 (1983).
- [8] P.M. Owens et al., *Anal. Chem.*, 54, 2344 (1982).
- [9] B.A. Roscoe, P.K. Hopke, *Anal. Chim. Acta*, 132, 89 (1981).
- [10] R. Hoogerbrugge et al., *Anal. Chem.*, 55, 1710 (1983).
- [11] E.R. Malinowski and D.G. Hower, *Factor Analysis in Chemistry*, J. Wiley and Sons, New York, 1980.
- [12] E.R. Malinowski, *Anal. Chem.*, 49, 612 (1977).
- [13] J.J. Kankare, *Anal. Chem.*, 42, 1322 (1970).
- [14] J.H. Kindsvater et al., *Anal. Chem.*, 49, 982 (1977).
- [15] E.R. Malinowski, *Anal. Chim. Acta*, 101, 339 (1978).
- [16] 王保宁, 分析化学, 3, 400 (1975); H.A. Flaschka, "Chelate in Anal. Chemistry", Marcel Dekker, INC., New York, Vol. 1, 1972.
- [17] C.K. Liu et al., *Am. Ind. Hyg. Assoc. J.*, 49, 314 (1983); J.M. Corkill, J.F. Goodman and T. Walker, *Trans. Faraday Soc.*, 61, 768 (1967).

EXTRACTION-ATOMIC ABSORPTION SPECTROMETRIC DETERMINATION OF RUBIDIUM AND CAESIUM IN BRINE

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 14 No 1, 20 Jan 86 pp 55-57

[English abstract of article by Shen Zhentian [3088 2182 1132], et al., of Qinghai Institute of Saline Lakes, Chinese Academy of Sciences]

[Text] The extraction of Rb and Cs by the substituted phenols, especially 4-t-butyl-2(α -methylbenzyl) phenol (BAMBP) has been studied. The optimum concentration of NaOH and BAMBP for the extraction of Rb and Cs is 1.0 M. If an appropriate amount of sodium tartrate is added as the masking agent before adding the other reagent, the precipitation of Mg or Fe can be prevented. This method has been successfully applied to the quantitative estimation of Rb and Cs in brines with lower detection limits than those of the general method. The relative error is ± 6 percent. The method is rapid, simple and sensitive. (Paper received 8 September 1984.)

REFERENCES

- [1] R.J.Everett and H.A.Mattola, *Anal.Chim.Acta*, 84(2), 143, 1971.
- [2] 沈振天, 陈克清等, 理化检验 (化), 待发表。
- [3] 沈振天, 刘福敏, 中国化学会1983年分析化学年会文集A-5 1983.8, 大连。

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CSO: 4009/1047

PHOTOACOUSTIC SPECTROSCOPY STUDIES OF LATTICE DAMAGE IN Si WAFERS

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
Vol 5 No 2, Apr 86 pp 81-87

[English abstract of article by Su Jiuling [5685 0046 0109], et al., of the
Department of Physics, Fudan University]

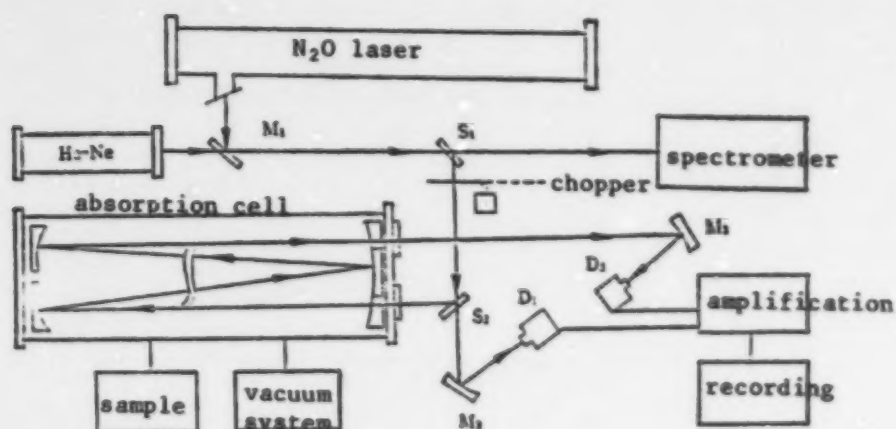
[Text] The effect of boron-implantation on Si wafers and the annealing behavior of ion-implanted Si wafers are studied by photoacoustic spectroscopy (PAS) and the results are reported. The change of the magnitude of lattice damages induced by boron implantation with doses ranging from 10^{12}cm^{-2} to 10^{15}cm^{-2} has been observed. After the annealing, the magnitude of residual defects in the damaged region is compared qualitatively. Comparison between normalized photoacoustic spectra of boron-implanted and phosphorus-implanted silicon wafers and aluminum-ground silicon wafers makes it clear that there are some differences between boron-implanted and phosphorus-implanted silicon wafers, and there are similar lattice damages to them under high doses. Comparison between the effects of conventional thermal annealing and rapid thermal annealing comes to the conclusion that the rapid thermal annealing is more effective than the conventional one in removing defects in an ion-implanted layer of Si wafers under certain circumstances. It is seen that PAS is a rapid, sensitive, convenient and nondestructive method for examining the lattice damage in Si wafers and the effectiveness of thermal annealing in the IC process.

PRESSURE SHIFTS OF 10.8 μm N_2O MOLECULAR SPECTRAL LINES

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
Vol 5 No 2, Apr 86 pp 89-92

[English abstract of article by Guo Zengxin [6753 1073 2946], et al., of the
Department of Physics, East China Normal University]

[Text] The pressure shifts of N_2O molecular absorption spectral lines are
observed and measured using a selected-branch N_2O laser and White-type
absorption cell. The measurements agree with the QFT theoretical calculations.



Experimental Setup

STUDY OF IR BROAD-BAND PRSA TYPE ELLIPSOMETER

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
Vol 5 No 2, Apr 86 pp 99-106

[English abstract of article by Zhang Keqi [1728 0344 1142], et al., of
Shanghai Institute of Technical Physics, Chinese Academy of Sciences]

[Text] The experimental set-up of an IR broad-band PRSA type ellipsometer developed by the authors and its measuring errors are described in detail. In particular, the influence of the limited extinction ratio and additional phase delay of the wire grid polarizers on measurement accuracy is analyzed. The typical results from the measurement of ZnS, ZnSe and PbTe layers are given in order to demonstrate the capabilities of this instrument.

FULLY AUTOMATIC SYSTEM FOR MEASURING I-V CHARACTERISTICS OF INFRARED
DETECTOR ARRAYS

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
Vol 5 No 2, Apr 86 pp 117-122

[English abstract of article by Chen Zhonggan [7115 0112 3927] of Kunming
Institute of Physics]

[Text] This system consists of a HP-85 computer, three instruments made by
Keithley Co., i.e., 195 DMM, 220 current source and 705 scanner, and a
multifunction measuring system made by the author, with software written for
running the system. This is a complete system which can make automatic
measurements and has the ability to treat elements with broken connections
or abnormal behavior.

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CSO: 4009/71

FLIP-FLOP SENSE AMPLIFIER WITH HIGH SENSITIVITY FOR HMOS-SRAM

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese, Vol 7
No 2, Mar 86 pp 121-127

[English abstract of article by Zhang Zhongxuan [1728 6988 1357], et al., of
Qinghua University]

[Text] A new sense amplifier for HMOS-SRAM is described. It is composed of a cross feedback source follower pair and is set at critical flip-flop state by precise control of the ratio of two transistor sizes. It is proved theoretically and experimentally that advantages of this circuit are high sensitivity, large common-mode region and low output common-mode level. When it is used in SRAM, excellent results are obtained. (Paper received 19 March 1985.)

REFERENCES

- [1] S. D. Kang *et al.*, *IEEE Journal of Solid-State Circuits*, **SC-16**, 444 (1981).
- [2] C. Rhodes *et al.*, *IEEE Journal of Solid-State Circuits*, **SC-16**, 594 (1981).
- [3] Tosi HO Wada, *IEEE Journal of Solid-State Circuits*, **SC-13**, 635 (1978).
- [4] M. J. Howes, D. V. Morgan, "Large Scale Integration", Chapter 6 (1981).
- [5] J. Wong *et al.*, *IEEE Journal of Solid-State Circuits*, **SC-16**, 435 (1981).
- [6] 张钟宣, "HMOS-SRAM 中一种新型高灵敏度读出放大器的设计与实验", 清华大学硕士学位论文 (1984).

INVESTIGATION OF BISTABLE CHARACTERISTICS OF SEMICONDUCTOR LASER WITH SINGLE CAVITY AND DOUBLE CONTACTS

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7 No 2, Mar 86 pp 136-146

[English abstract of article by Wang Shouwu [3769 1343 2976], et al., of the Institute of Semiconductors, Chinese Academy of Sciences]

[Text] The bistable behavior of a laser with a single cavity and double contacts calculated numerically based on consideration of interband absorption with K selection rule starting from the multimode rate equations is reported. Systematic analysis of various factors which affect the two important parameters of the device (width of the bistable injection region and response time) is also reported. (Paper received 20 May 1985.)

REFERENCES

- [1] G. J. Lasher, *Solid-State Electron.*, **7**, 707 (1964).
- [2] N. G. Basov, *IEEE J.*, **QE-4**, 855 (1968).
- [3] T. P. Lee and H. R. R. Roldon, *IEEE J.*, **QE-6**, 339 (1970).
- [4] H. Kawauchi, *IEE Proc.*, **129**, 141 (1982).
- [5] Ch. Harder, K. Y. Lau and A. Yariv, *IEEE J.*, **QE-18**, 1351 (1982).
- [6] 王启明, *通信学报*, **6**, 65 (1985).
- [7] 王启明, 朱龙德, 曹其岸, *物理学报*, **34**, 1102 (1985).
- [8] F. Stern, *J. Appl. Phys.*, **47**, 5382 (1976).
- [9] 王启明, 杜宝勋, *半导体通讯(内部刊物)*, 第4期, 第25页 (1979).

OPTICAL BISTABILITY AND SWITCHING CHARACTERISTICS OF GaAs/GaAlAs pnpn
NEGATIVE RESISTANCE LASER

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 2, Mar 86 pp 147-153

[English abstract of article by Wang Shouwu [3769 1343 2976], et al., of the
Institute of Semiconductors, Chinese Academy of Sciences]

[Text] Reported for the first time are some experimental results regarding
the optical bistability and switching characteristics of a pnpn type GaAs/
GaAlAs laser device. Based on the double phototransistor model, a general
analysis is given of the physical description of the optical bistability and
switching operations in the device. (Paper received 21 May 1985.)

REFERENCES

- [1] C. Harder, K. Y. Lau and A. Yariv *IEEE Q-E*, QE-18, 1351 (1982).
- [2] S. D. Smith and A. C. Walker, *ICO-13*, B5-10, 447 (1984).
- [3] H. Kawaguchi and G. Iwane *Electronics Letters*, 17, 167 (1981).
- [4] H. M. Gibbs et al., *Appl. Phys. Lett.*, 33, 431 (1979).
- [5] A. Kio Sasaki et al., *IEEE Trans.*, ED-29, 1382 (1982).
- [6] K. Y. Lau and A. Yariv *Appl. Phys. Lett.*, 45, 719 (1984).
- [7] 王守武, 吴荣汉, 朱其高, 张权生, 李照银, 田惠良, 电子学报, 2, 35(1979). *IEE Proc.*, 129, 806 (1982).
- [8] T. Morizumi and K. Takahashi *IEEE Trans.*, ED-19, 152 (1972).
- [9] 王守武, 张权生, 李照银, 吴荣汉, *IEE Proc. Optoelectronics*, 122, Part J, 60(1985).

SHALLOW IMPURITY STATE IN GaAs-Ga_{1-x}Al_xAs SUPERLATTICES

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 2, Mar 85 pp 164-173

[English abstract of article by Ma Delu [7456 1795 6922], et al., of the
Department of Physics, Liaoning University]

[Text] Binding energies of the ground state of a shallow impurity in real GaAs-Ga_{1-x}Al_xAs superlattices with a large number of equal thickness alternating layers are calculated using a variational approach. In our calculations, the effects due to different effective masses and dielectric constants in GaAs and Ga_{1-x}Al_xAs layers and the non-parabolicity of GaAs conduction bands are included. The binding energy is calculated as a function of layer thickness and exhibits only one peak as Chaudhuri expected. For very thin superlattices the binding energy approaches a stable value.

The corresponding quantity in the case of three quantum wells is also calculated and compared with Chaudhuri's results. It is shown that when $x = 0.4$, the correction of the main peak value of binding energy exceeds 16 percent. (Paper received 4 March 1985.)

REFERENCES

- [1] B. V. Shanabrook, J. Comas, T. A. Perry and Metlin, *Phys. Rev.*, B29, 7096 (1984),及其所引文献.
- [2] S. Chaudhuri, *Phys. Rev.*, B28, 4480 (1983).
- [3] 刘振鹏, 半导体学报, 4, 313(1983).
- [4] Zhenpeng, Liu and D. L. Lin, *Phys. Rev.*, B28, 4413 (1983).
- [5] 刘振鹏, 李天克, 半导体学报, 6, 32(1985).
- [6] T. Ando and S. Mori, *J. Phys. Soc. Japan*, 47, 1518 (1979).
- [7] T. Ando and S. Mori, *Surf. Sci.*, 113, 124 (1982).
- [8] R. de L. Kronig and W. G. Penny, *Proc. Roy. Soc. (London)*, A130, 499 (1931).
- [9] R. L. Greene and K. K. Bajaj, *Solid State Commun.*, 45, 825 (1983).
- [10] S. Chaudhuri and K. K. Bajaj, *Phys. Rev.*, B29, 1803 (1984).
- [11] H. A. Kramers, *Quantum Mechanics*, North-Holland Publishing Company-Amsterdam p. 54 (1957).
- [12] C. Mailhot, Y. C. Chang and T. C. McGill, *Phys. Rev.*, B26, 4449 (1982).
- [13] K. Tanaka, M. Nagaoaka and T. Yamabe, *Phys. Rev.*, B28, 7068 (1983).
- [14] L. D. Landau and E. M. Lifshitz, *Quantum Mechanics*, Third-edition, Pergamon Press, p. 60(1977).
- [15] 曾谨言, 量子力学(上册), 科学出版社, p.95 (1984).

COMPUTER REAL TIME CONTROLLED SYSTEM FOR EXPERIMENTAL STUDIES IN SOLID STATE ELECTRONICS

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7 No 2, Mar 86 pp 202-208

[English abstract of article by Bai Guang [4101 0342], et al., of the Graduate School, University of Science and Technology of China]

[Text] A fully automatic computer controlled system for experimental studies in solid state electronics is designed and implemented. A HP87 microcomputer is used as a controller, interfacing with intelligent measuring instruments via IEEE 488 interfaces. The system is actually a highly parallel processing system consisting of multiprocessors included in the central controller and intelligent instruments to overcome the low speed disadvantage of the controller. Thus, the system is very powerful and flexible for solid state electronics experiments and is reasonably priced. A highly efficient DLTS measurement is described as an illustration. (Paper received 15 February 1985.)

REFERENCES

- [1] B. J. Gordon, *IEEE Trans.*, ED-27, 2268 (1980).
- [2] E. E. Wagner, D. Hill and D. E. Mars, *Rev. Sci. Instrum.*, 51, 1205 (1980).
- [3] P. D. Kirchner, W. J. Schaff, G. N. Marcus, L. F. Fastman, T. I. Chappell and C. M. Ranson, *J. Appl. Phys.*, 52, 6462 (1981).
- [4] T. R. Jervis, W. M. Tetex, T. Cole and D. Dunlavy, *Rev. Sci. Instrum.*, 53, 1160 (1982).
- [5] K. Asada and T. Sugans, *Rev. Sci. Instrum.*, 53, 1001 (1982).
- [6] M. F. Li (李名复) and C. T. Sah, *IEEE Trans.*, ED-29, 306 (1982).
- [7] M. D. Jack, R. C. Park and J. Henriksen, *IEEE Trans.*, ED-27, 2226 (1980).
- [8] 李名复、陈建新、姚玉书、白光, 磁中金受主能级的流体静压移动, 待发表于物理学报.
- [9] D. V. Lang, *J. Appl. Phys.*, 45, 3023 (1974).
- [10] L. D. Yan and C. T. Sah, *Phys. Status Solidi*, A6, 561 (1971).
- [11] H. Lefevre and M. Schultz, *Appl. Phys.*, 12, 45, (1977).

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STABILITIES OF ROTATIONAL DISCONTINUITY FOR MAGNETOPAUSE

Beijing KONGJIAN KEXUE XUEBAO [CHINESE JOURNAL OF SPACE SCIENCE] in Chinese
Vol 6 No 2, Apr 86 pp 89-96

[English abstract of article by Wang Shui [3769 3055], et al., of the
Department of Earth and Space Sciences, University of Science and Technology
of China]

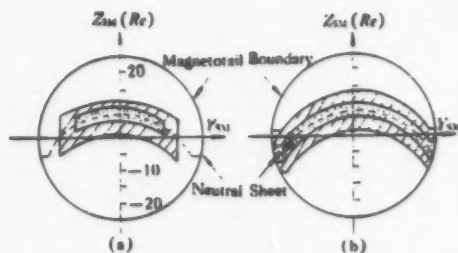
[Text] Using a three-layer model and observations from Satellite ISEE, the stabilities of rotational discontinuity for magnetopause are discussed. The results show that: (1) a kind of instability may be excited in the magnetopause rotational discontinuity, and the growth rate of the instability increases as the wave number k increases; (2) when the interplanetary magnetic field is northward, the magnetopause rotational discontinuity is stable; when the interplanetary magnetic field becomes southward gradually, the growth rate of the instability increases rapidly; (3) when the velocity of the solar wind is larger, the growth rate of instability is correspondingly larger; (4) when the interplanetary magnetic field is southward, the growth rate of instability increases rapidly as the angle between the interplanetary magnetic field and the tangential surface of the magnetopause increases.

SOME STATISTICAL RESULTS OF ENERGETIC PARTICLE PULSES IN MAGNETOTAIL

Beijing KONGJIAN KEXUE XUEBAO [CHINESE JOURNAL OF SPACE SCIENCE] in Chinese
Vol 6 No 2, Apr 86 pp 97-101

[English abstract of article by Wu Jiping [0702 1376 5493] of the Institute of Space Physics, Chinese Academy of Sciences]

[Text] This paper presents the results of correlation analysis between the data of energetic particle pulses obtained by the IMP-J spacecraft (P4: $230 \text{ keV} > E > 160 \text{ keV}$) and auroral electrojet index AE. The magnetotail is divided into three regions: neutral sheet region, low latitude region and high latitude region. It is found that: (1) In the neutral sheet region, the average energetic particle flux is the highest among all three regions. In the high latitude region the flux is the lowest. This indicates that the "source" of energetic particle pulses may be located in the neutral sheet region. (2) The correlation between energetic particle pulses and the AE index is most significant in the neutral sheet region, with the correlation coefficient R being 0.59. In low and high latitude regions, R decreases sharply. This coincides with the idea that energetic particle pulse event is the substorm relevant event, and that the particles are accelerated by an induced electric field caused by the magnetic field line reconnection near the neutral sheet region. (3) The accelerated area is limited to a thin layer around a neutral sheet, which coincides with Hones' results.



SOME OBSERVATION RESULTS OF RADIATION BELT ELECTRONS FROM SATELLITE-BORNE
SEMICONDUCTOR TELESCOPE

Beijing KONGJIAN KEXUE XUEBAO [CHINESE JOURNAL OF SPACE SCIENCE] in Chinese
Vol 6 No 2, Apr 86 pp 147-151

[English abstract of article by Cheng Dongyuan [4453 2767 0337], et al., of the
Institute of Space Science, Chinese Academy of Sciences]

[Text] By analysis of observation data from instruments on board Chinese satellites, the typical omnidirectional fluxes of inner belt electrons with energy higher than 0.5 MeV and 1.0 MeV as 1.9×10^8 and 6.7×10^7 ele/s·cm² respectively are obtained. A profile of electron flux on a typical orbit is also given. In addition, the omnidirectional fluxes with the same energy ranges at the synchronous altitude obtained from the first Chinese geostationary satellite are 2.43×10^6 and 4.25×10^5 ele/s·cm² respectively. At the same time, the diurnal variations of electron flux of the outer radiation belt are also given and they are essentially agreeable with the observations made abroad.

DESIGN AND CONSTRUCTION OF HIGH PRECISION PRISM SUN SENSOR

Beijing KONGJIAN KEXUE XUEBAO [CHINESE JOURNAL OF SPACE SCIENCE] in Chinese
Vol 6 No 2, Apr 86 pp 152-157

[English abstract of article by Xiao Gongbi [5135 0501 1732], et al., of the
Institute of Automation, Chinese Academy of Sciences]

[Text] In carrying out a project developing an astronomical satellite, a prototype of a high precision prism sun sensor was designed and constructed. The principle of prism solar position measurement is proposed. Using this principle and such methods as energy balance measurement, compensation of the variation of irradiance, etc., a high precision measurement of solar position is realizable. A sun sensor designed with this principle has high resolution and precision in small view fields, small size, light weight and long service life. According to the conclusion of a formal evaluation, such an instrument has a resolution of 1" and a precision of $\pm 3''$ in a view field of $\pm 70'$. The entire system weighs 2.5 kg and requires 1 watt of power consumption.

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CSO: 4009/73

PROVINCIAL VARIATION OF URBANIZATION IN CHINA

Beijing JILI XUEBAO (ACTA GEOGRAPHICA SINICA) in Chinese Vol 41, No 1,
Mar 86 pp 8-21

[English abstract of article by Xu Xueqiang of Zhongshan University and
Gar-on Yeh of Hong Kong University]

[Text] China's cities belong to the clustered pattern, examining them by Kolmogorov-Aminov formula and the Lorenz curve. The highest density of cities and towns has happened in Shanghai municipality: 56.77 cities and towns per 10,000 km². Zhejiang and Jiangsu Provinces occupy second and third places, according to the density of urban settlements: 17.06 and 11.67 cities and towns per 10,000 km² respectively. The lowest density indexes of cities and towns are found in Xizang Autonomous Region and Qinghai: 0.08 and 0.12 respectively. The density of cities and towns is regularly reducing from East to West in China. The provincial variation of the density of cities and towns can be explained by the regression techniques. A correlation coefficient of 0.87 has been obtained by the regression analysis of the density of cities and towns, in which the population density as independent variable. In provinces and autonomous regions, the greater the population density, the greater the density of cities and towns. A multiple correlation coefficient is 0.96, which was found by multiple regression analysis of the density of urban settlements with the gross industrial and agricultural output value, per capita industrial output, the index of the railway length, per rural person grain output, and population density as independent variables. These five variables can explain 92 percent of the provincial variation of the density of urban settlements.

Because the urbanization is measured by the proportion of urban population to the provincial total ones, the urbanization level of those provinces with concentration of urban settlements and urban population seems to be not so high. Most of the relatively high urbanized provinces and autonomous regions are located in Northeast, North and Northwest China, while the provinces with moderate and lower urbanization level are found in the East, Central and South provinces. Variables of population density, size of area, and industrial-agricultural output ratio, per capita industrial output, per capita agricultural output, per capita total production output can be used for reflection of provinces' population and economic characteristics respectively. Two factors are identified by factor analysis with varimax

rotation. The first factor is industrialization that measures the levels of industrialization and productivity and the second factor is population density that reflects the general population distribution characteristics of a province or an autonomous region. As these two factors are orthogonal to each other, it suggests that there is no direct relationship between the industrialization level with population size or density in every province or autonomous region. A multiple correlation coefficient of 0.863 has been obtained by multiple regression analysis between urbanization level with the factor scores of industrialization level and population density as independent variables. These two factors could explain 74.5 percent of the provincial variation of urbanization level. The urbanization level of a province or an autonomous region is related positively with industrialization level but negatively with population density. The industrial distribution policy encourages urbanization for the less densely populated Northeast, North and Northwest provinces and autonomous regions. To a certain extent, the control of urban population discourages urbanization for the densely populated East.

There is big variation in the primacy index of the provinces in China. It ranges from 1.009 in Anhui to 10.23 in Qinghai (in 1982). The provinces and autonomous regions with high primacy index are mainly concentrated in the Northwest and Southwest regions of China, except Guangdong and Hubei Provinces. The indexes of provinces and autonomous regions in West China have increased since liberation, but in recent years, they have begun to fall in some provinces and autonomous regions. Most of the Northeast, East, North, and Central South provinces have moderate or low primacy indexes, which have declined since liberation. The provincial variation of the urban primacy index may be explained by the urban development history, the development potential of the primacy city in provinces, the national industrial distribution policy and different stages of the economic development of provinces and autonomous regions.

In recent years, due to practising the open policy to the outside world the policy permitting peasants to go into towns to do businesses on the basis of self food supply and other policies as well, the urbanization process has been speeded up, urban primacy index has been relatively raised in some provinces and autonomous regions, and the development of small towns has been greatly made.

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CSO: 4011/43

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24 JULY 1986

China Report

SCIENCE AND TECHNOLOGY



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24 JULY 1986

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SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

TRENDS IN S&T TECHNOLOGY IMPORTS DETAILED

Beijing GUOJI SHANGBAO in Chinese 24 April 86 p 1

[Report by Yan Huimin [7346 1979 3046]: "Four New Changes in China's Technology Imports"]

[Text] There has been great development in China's importation of technology over the past few years. According to preliminary statistics, during the period of the "Sixth 5-Year Plan," \$9.2 billion in foreign currency was used to import technology, a 61.4 percent increase over the period of the "Fifth 5-Year Plan," and a large number of technology import projects were completed and put into production, which played an important role in our economic construction and in improving the standard of living for the people. During the "Seventh 5-Year Plan," relevant sectors will focus on exploring new forms and new methods for the importation of technology, which will allow the importation of technology to be greatly improved in the area of quality.

During the period of the "Sixth 5-Year Plan," the scale of our importation of technology continued to expand, and there were new changes in what was imported and the means by which it was done. For the most part, those changes were evidenced by:

1. The focus of technology importation progressively shifted from primarily importing large scale sets of equipment to build new factories to importing new technology and key equipment for the technological transformation of existing enterprises. Target areas developed in the direction of the small scale and toward the highly technology intensive, and toward a high regard for economic results and in improving product quality and expanding commodity exports.
2. The formats of technology importation developed toward the more diverse. Among the various technology importation contracts signed with foreign interests, 60 percent were contracts for trade licensing, cooperative production, advising and consulting, and technical service. In the second phase of the Baogang project in Shanghai, the majority of items made use of the formats of cooperative design and cooperative manufacture and the proportion of manufacturing for the Chinese side was expanded, which both saved expenditures of foreign exchange for this country, and also enhanced our own capacity for manufacturing equipment.

3. The professions for which technology has been imported developed toward even broader fields. The 20 sectors that include machinery, electronics, chemical engineering, light industry, petroleum, coal, building materials, metallurgy, vehicles, hydroelectricity, and textiles were all involved. For the machinery and electronics industries, importation of matched parts, components, and basic parts for production techniques and for manufacturing technology have developed most quickly.

4. The list of countries from which technology is imported has become more varied. In the past, the sources of technology imports have primarily concentrated on a few countries. Last year, in addition to Japan, West Germany, and the United States, the sources for much imported technology were France, Italy, England, Switzerland, Sweden, Denmark, Austria, and Eastern European countries. Some countries have also taken appropriate steps to relax the restrictions on exports from our country.

12586

CSO: 4008/2112

NATIONAL DEVELOPMENTS

FUJIAN IMPORTS OPTICAL FIBER EQUIPMENT FROM ITALY

OW080259 Fuzhou FUJIAN RIBAO in Chinese 26 May 86 p 1

[By FUJIAN RIBAO reporter Chen Huibo]

[Text] A contract was signed at the restaurant of Fuzhou's foreign trade center on 25 May between the Fujian Administration of Posts and Telecommunications and Italy's (Taletera-Pirelli) Company on the import of equipment need for the completion of the first-stage Xiamen-Nanping optical fiber telecommunications project.

The first-stage Xiamen-Nanping optical fiber telecommunications project (Nanping--Yongan Sector) calls for the import of 1,920 circuits x 2 optical fiber cable and the equipment for the relative photo cell converter system. The provincial administration of posts and telecommunications finally decided to import the equipment from the (Taletera-Pirelli) Company under Italy's Fiat Group.

Attending the contract-signing ceremony were You Dexin, vice governor of Fujian; and Lin Jinquan, head of the provincial administration of posts and telecommunications; as well as Italian Ambassador to China Marras, and (Kasoli), manager of the International Department of Italy's Fiat Group.

Before the ceremony began, Xiangnan, you Dexin, and He Minxue met with Ambassador Marras and Mr (Kasoli). (Kasoli) and the other Italian guests also discussed issues of cooperation with the comrades from the provincial Economic Commission and the provincial Commission for Foreign Economic Relations and Trade.

The set of optical fiber telecommunications equipment from Italy is expected to arrive after September 1986. It will be installed, and put into operation in August 1987.

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CSO: 4008/1081

NATIONAL DEVELOPMENTS

CHEMICAL INDUSTRY NEEDS IMPORTED TECHNOLOGY

CW010620 Beijing XINHUA in English 0610 GMT 1 Jun 86

[Text] Beijing, 1 Jun (XINHUA)--Importing advanced technology for producing urgently needed chemicals is one of the priorities of the 7th five-year plan that starts from this year, said an official of the China National Chemical Engineering Corporation (CNCEC).

An Yuzong, general manager of CNEC said China expects to import equipment for extracting chemical deposits and for manufacturing compound fertilizer, basic chemical materials and refined chemicals.

Deals may be conducted in technical transfers, cooperative production, joint ventures, technical services and consultation and compensation trade, An said.

Last year, the corporation imported 108 projects and signed 248 contracts with overseas firms. Imports in this field have been shifted from complete sets of equipment to single key components, from importing whole factories to only the technology needed for updating old enterprises and from using single form of cooperation to using a variety of forms.

An said that China's export of chemical technology has also increased and he expects further growth in China's chemicals exports in the next five years.

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CSO: 4010/1046

NATIONAL DEVELOPMENTS

SHANGHAI URGED TO STRESS PRODUCTION FOR EXPORT

OW221436 Beijing XINHUA in English 1412 GMT 22 Jun 86

[Text] Shanghai, 22 Jun (XINHUA)--Economists suggested Shanghai should build export-oriented production systems to promote its exports which had come to standstill for four years from 1982 according to a meeting here.

More than 100 experts from the State Council and Shanghai attended the three-day meeting which closed Saturday. It focused on Shanghai's implementation of the opening policy and development.

Experts said that Shanghai should first set up an export-oriented textile system as one third of textile enterprises there produce goods for export at present. "Textiles earn 1.8 billion U.S. dollars a year now, about a half of Shanghai's foreign exchange", the meeting was told.

"Textile enterprises are now preparing to organize enterprise groups and then set up a system integrating production with foreign trade," said Mei Shouchun, director of the Municipal Textile Bureau.

Experts estimated that the system will help increase Shanghai's textile exports from 1.8 billion to 2.5 billion U.S. dollars by 1990.

Though machinery only yields 300 million U.S. dollars a year, the industry which takes up one-third of the city's total industrial output value has a great potential for export.

During the 1986-90 period, Shanghai should streamline 100 major plants to increase exports or power generating equipment, machine-tools, tractors, medical apparatus, textile machines, bicycles, wrist watches and cameras. Those products are expected to earn 600 million U.S. dollars by 1990, doubling the current figure, according to the meeting sources.

Experts also suggested to expand export-oriented farm produce centers which will triple the current export quantity worth nearly 100 million U.S. dollars.

When discussing high-technology product centers for export, the meeting was told that by the end of the seventh five-year plan period (1986-90), micro-electronics, optical-fibre communications, new materials, laser and bio-engineering industries will produce an annual output value of three billion yuan and become foreign exchange earners by the end of the century.

"Establishment of the export-oriented system will help reform the current foreign trade management," said Uan Zengwei, an expert from the Shanghai economic research center.

Under the old management system, manufacturers learned less information on international market and requirements of importers and their products, thus, are less competitive due to the separation between industrial enterprises and trade businesses.

In recent years, about 1,000 enterprises have integrated production with foreign trade.

Ju Chongwei, an official from a research center of the State Council, stressed that establishment of export-oriented production systems is a "strategic measure" of China for expanding exports.

"Only through expansion of exports, Shanghai will be able to import more equipment, technology and use more foreign funds," vice-mayor Li Zhaoji said.

Shanghai produces one-ninth of China's manufactured goods and one-sixth of China's exports. During the 1980-85 period, Shanghai's export volume were standstill for four years, though it earned total foreign exchange of 18 billion U.S. dollars during that period, a 20 percent growth over the previous five-year period.

According to the seventh five-year plan, Shanghai's exports will grow 8.6 percent a year, amounting to 4.3 billion U.S. dollars by 1990, the meeting was told.

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CSO: 4010/1046

NATIONAL DEVELOPMENTS

ELECTRONICS INDUSTRY MINISTER VIEWS DEVELOPMENTS

HK031231 Beijing GUANGMING RIBAO in Chinese 24 Jan 86 p 2

[Report by Liu Sa [0491 7366]: "AP Interview With the Minister of Electronics Industry"]

[Text] At the recent meeting of leading cadres in charge of the electronics industry, this reporter interviewed Li Tieying, minister of electronics industry on the question of how to invigorate our electronics industry by means of technological progress. He answered the following questions put by this reporter.

Question: How do you appraise the present situation in China's electronics industry?

Answer: Like China's economic situation as a whole, the present situation in its electronics industry is the best since the founding of the republic. Important signs of the situation are: 1) We have overfulfilled the "Sixth 5-Year Plan" in advance, in an all-round way. 2) We have achieved good results in scientific research and improved the quality of a number of electronics products. 3) Major successes have been achieved in capital construction, technological transformation and technological imports. 4) Through readjustments in the structure of production and the orientation of service, a bright future for an upward trend in the electronics industry has emerged. 5) There has been a good beginning in improving major relations in the development of electronics industry and raising the level of operations and management. 6) Through tremendous efforts to reform the economic structure and the systems of scientific and technological work and education, our electronics industry has embarked on a path of professional management. 7) Our further efforts in enterprise consolidation have strengthened the leading bodies of enterprises and enhanced the quality of cadres and workers. All this has laid a sound foundation for the development of electronics industry during the "Seventh 5-Year Plan." Meanwhile, the increasing needs of customers at home and abroad for electronics products will prompt enterprises to bring about better economic results and social benefit by giving full play to the existing capacity in scientific research and production. The present good situation in our country strengthens our confidence in promoting the development of the electronics industry.

Question: What are the targets set for the electronics industry in the "Seventh 5-Year Plan"?

Answer: To sum up, the tasks set in the "Seventh 5-Year Plan" are: One is to carry out reforms and the other is to promote development. The general goal for the development of the electronics industry is build it into a base for providing technological equipment for the national economy and national defence and improving the people's material and cultural lives. By 1990, it is expected that the total output value of our electronics industry will make up 3 to 4 percent of the country's industrial and agricultural gross output value, increasing at an annual average rate of about 16 percent. The taxes and profits delivered to the state will increase by 95 percent over 1985 and all-member labor productivity and foreign exchange earnings through exploration will be doubled. We will strive to raise the technical level and quality of our products to that of foreign products by the end of the 1970's and early 1980's. We have also set tasks and targets for reform of the economic structure in electronics industry.

Question: In the development of our electronics industry, are there any difficulties and problems for technological progress?

Answer: As a newly-emerged industry, our electronics industry has the following major problems: 1) We lag behind in microelectronics and computers, which are the most advanced technologies in the contemporary electronics industry. Meanwhile our electronics products are not so competitive because there is still a big gap between the quality of our products and that of foreign products. 2) The proportion of electronics products used for technological transformation in the national economy is small and electronics technology is not fully and extensively used in the national economy. 3) Our ability to absorb foreign advanced technology and independently develop the industry is limited. 4) The development of intellectual resources, and both the quantity and quality of trained people, cannot meet the needs of the development of the electronics industry. Furthermore we are short of funds for technological transformation and scientific research. All these are difficulties and problems which we have to overcome for the technological progress of our electronics industry.

Question: How does the Ministry of Electronics Industry plan to invigorate China's electronics industry by means of technological progress?

Answer: To develop new electronics technology, we will concentrate trained people and funds on establishing a number of modern scientific research centres and experimental units so as to promote the scientific and technological achievements to be used in production. Priority will be given to five major technologies--computers, integrated semiconductors, electronics for telecommunications and industry, and modern military electronics. Efforts will be made to narrow the gap between our level of major technologies and the world level. We will also readjust and reorganize the existing research institutes and build them into more concentrated scientific research organizations with multi-levels. We will select some good research institutes to engage specifically in the advanced scientific research of microelectronics,

computer, software, telecommunications, industrial electronics and military electronics in an effort to develop new technologies and new products and popularize their achievements. We will also intensify our work on quality checks of electronics products by applying international stands during the "Seventh 5-Year Plan." Ten quality-check centres will be built so that the reliability of our electronics products can be ensured and their quality can be improved. Meanwhile, we will pay attention to promoting the best products first, introducing the system of standarizing the technical equipment of enterprises and promoting rationalization of production. We will attach great importance to the development of intellectual resources, hugely increase investment in education and give full play to the enthusiasm of different sectors in training personnel for the electronics industry. Furthermore, we will also promote international exchanges and send more scientific and technological personnel abroad to pursue advanced studies. Finally, one point must be made clear. The technological advance of the electronic industry should earn vigorous support from other fraternal departments, and particularly from departments supplying industrial raw materials.

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CSO: 4008/1081

NATIONAL DEVELOPMENTS

CHINA'S FIRST ROBOT RESEARCH CENTER BEING BUILT IN SHENYANG

OW311150 Beijing XINHUA in English 1132 GMT 31 Jan 86

[Text] Beijing, 31 Jan (XINHUA)—China's robot research and development center is now under construction at the Shenyang Institute of Automation attached to the Chinese Academy of Sciences.

Jiang Xinsong, director of the automation institute, told XINHUA here today that his institute in 1985 developed China's first underwater robot which can work at a depth of 200 meters.

Jiang is attending a working meeting of the science academy in Beijing.

He said China began research on robots in the 1970s and now has some 1,000 industrial manipulators and a few industrial robots, used in the fields of casting and forging, punching and heat treatment.

A graduate of Jiaotong University in Shanghai in 1956, Jiang has been engaged in research on automation, industrial control, artificial intelligence and robots for nearly 30 years.

He said robots can do some work unable to be done by man under high-temperature, poisonous and dangerous conditions.

So it is imperative to develop robots in China, he said, but the application of robots does not mainly aim at saving manpower.

China lags behind other countries such as Japan and the United States in developing robots. Jiang's view is that in research and development, China must take a road suited to its own conditions.

First of all, Jiang said, China should develop low-priced simple robots (manipulators) for raising working efficiency and reducing labor intensity. Secondly, it should develop special-purpose robots, including movable robots to work in poisonous environments, handle accidents and inspect equipment, and remote-control robots for underwater, and rescue operations and coal mining.

He expressed the view that, while introducing technology for first-generation robots from abroad, China should develop sensor equipped second-generation robots so as to reduce the gap with the advanced countries in the field.

Robot research and development has been listed as one of the country's major scientific research projects for the seventh five-year plan period (1986-1990), mainly focusing on the manufacture of industrial robots for paint-spraying, point and arc welding, and cargo-carrying.

Jiang said the production of robots involves machine-building, microscopics, control, information processing, bionic and dynamic technology. So the state must concentrate necessary funds and technical forces and take related measures to support the development of the robot industry.

The state-invested center will cover an area of eight hectares and has a floor space of 40,000 square meters, including factory buildings with numerical-control equipment and computer-aided design systems, a robot performance laboratory and a pool, 25 meters long, 25 meters wide and 12 meters deep.

Jiang said the center's main task is to develop technology for special-purpose robots. In the next five years, the center will develop underwater robots in series which can dive to depths from 300 to 600 meters, and movable remote-control robot prototypes.

By 1990, the number of researchers and scientists at the center will be 400, as against 100 at present, including 100 Chinese and foreign non-resident researchers.

He also stressed the basic research conducted at the center, with a view to preparing technological reserves for developing non-cable underwater robots able to operate at depths of 2,000 meters, and remote-control robots for coal mining in the 1990s.

He said China should expand exchanges and cooperation with foreign scientists in robot research and development. So far, the Shenyang Institute of Automation has imported underwater robot manufacturing technology from Perry Offshore Inc. of the United States, and is now discussing cooperation in the field with the National Research Center of France.

/7051

CSO: 4010/1048

NATIONAL DEVELOPMENTS

UN SPACE COMMITTEE REACHES CONSENSUS ON REMOTE SENSING ACCORD

OW140314 Beijing XINHUA in English 0005 GMT 14 Jun 86

[Text] United Nations, 13 Jun (XINHUA)--The Outer Space Committee of the United Nations today adopted with a consensus the draft principles relating to remote sensing of the earth from outer space, a great achievement after 12 years' efforts made by the committee.

The term "remote sensing" means that satellite, by making use of the property of electromagnetic waves reflected by sensed objects, senses the earth's surface from outer space, for the purpose of improving natural resources management, land use and protection of the environment.

Since 1974, the legal sub-committee of the Outer Space Committee of the United Nations began to discuss the principles relating to remote sensing of the earth from outer space in an attempt to provide common rules governing remote sensing activities in outer space to be observed by all states, to promote the development of remote sensing technology and activities by satellite, and to develop international cooperation in this field.

The draft principles adopted today stressed that "remote sensing activities shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic, social or scientific and technological development, and taking into particular consideration the needs of the developing countries."

The document stipulates that states carrying out remote sensing activities shall promote international cooperation in the field, making available to other states opportunities for participation therein based on "equitable and mutually acceptable terms."

It says that "remote sensing shall promote the protection of the earth's natural environment." States possessing information that is capable of averting any phenomenon harmful to the earth's natural environment shall disclose such information to states concerned.

The document states that "remote sensing shall promote the protection of mankind from natural disasters." States possessing data and information that may be useful to states affected by natural disasters, or likely to be affected by impending natural disasters, shall transmit such data and information to states concerned as promptly as possible.

It stipulates that "as soon as the primary data and the processed data concerning the territory under its jurisdiction are produced, the sensed state shall have access to them on a non-discriminatory basis and on reasonable cost terms."

The document declares that "any dispute resulting from the application of these principles shall be resolved through the established procedures for the peaceful settlement of disputes."

Commenting on the draft principles, Chinese delegate He Qizhi said at the committee that the document "is a product of compromise of relevant parties," but "on the whole, the draft text is a rather practicable one, taking into account the interests of relevant sides. It is also a better result which could be reached at present." [sentence as received]

/9604

CSO: 4010/61

NATIONAL DEVELOPMENTS

DEFENSE INDUSTRY MODERNIZATION PROGRESS DISCUSSED

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 11 May 86 p 2

[Article extracted from the JINGJI RIBAO: "New Areas for National Defense Industries to Serve Modernization"]

[Text] After adjustments and reforms during the "Sixth 5-Year Plan," China's national defense industries and enterprises have taken a very important step on the road to integration of the military with the civilian. And there were remarkable changes in commodity structures, this situation shows that under the influence of the restructuring, invigoration, and open-door policies, the series of measures taken by the state to enliven enterprises has already motivated the enthusiasm of cadre and staff in the national defense industries that have been stagnant for a long time. This sort of enormous potential that was dormant for so long will develop even more to become a new production force.

But we must also notice that production of civilian goods by the national defense industry has after all just begun, there are still many problems, primary among which are: industrial structures, commodity structures, production capacity structures, and enterprise organization structures are not yet completely rational; the technological foundation for civilian goods that are self-developed and use highly intensive manufacturing technologies is still rather weak; intellectual development and personnel training still cannot meet the needs for guaranteeing military tasks while shifting to civilian production; product quality has not sufficiently stabilized, consumption of resources and raw materials is high, and economic results have been rather slow in improving. These problems all require earnest resolution in actual practice.

For the military industry and enterprises to develop production of civilian goods, the "four services" must be achieved, i.e., serving primary projects that develop the national economy, serving invigoration of local economies, serving the lives of the people, and serving trade exports. To this end, we must adopt development strategies that are adapted to the requirements of the international marketplace and yet suit our national situation in the areas of export commodity structures, exploitation of the international marketplace, and construction of an export commodity base, and we must greatly enhance the development of export commodities. If we are to evolve from "sell whatever we

have" to "arrange for the manufacture and production of whatever the marketplace needs," there must be new products, good quality, reasonable pricing, and timely delivery of goods.

In the situation in which there is a daily reduction in production tasking for military goods and in prescriptive planning, the military industrial system must realize the full enthusiasm in the tasking just described of both sectors and local areas, and must work toward lateral economic relations. On the one hand, responsible departments must create an excellent production and operations environment for externally strengthening enterprise vitality; in another sense, existing military industries and enterprises should all be like civilian enterprises in implementing factory director responsibility systems, in intensifying comprehensive reforms within enterprises, in implementing hierarchical and specialized management, in making accounting units smaller, establishing economic responsibility systems at different levels, making full use of the advantages of national defense industries in "changing tracks and altering forms," and coming up with more outstanding results during the period of the "Seventh 5-Year Plan."

12586

CSO: 4008/2112

NATIONAL DEVELOPMENTS

BEIJING PLAYS HOST TO AERODYNAMICS CONFERENCE

OW230930 Beijing XINHUA in English 0738 GMT 23 Jun 86

[Text] Beijing, 23 Jun (XINHUA)—More than 200 Chinese and foreign experts gathered today at the Beijing Science Hall to compare notes on the latest research about the fluid dynamics of high-speed missiles, rockets, planes, and satellites.

The 10th international conference on numerical methods in fluid dynamics, sponsored by the Chinese Aerodynamics Research Society, is the first of its kind held in Asia.

Research on numerical methods includes flow fields around missiles, rockets, planes and satellites, shock wave movement of nuclear explosion, atmospheric movement, transsonic flow, and turbulence flow.

During the 5-day conference, the participants from 18 countries and regions including Britain, France, Italy, Japan, the United States, the Soviet Union and China will present 132 papers dealing with numerical simulation of flows around the flying bodies, numerical methods in fluid dynamics, accuracy of numerical solutions, boundary layer flows and vortex flows.

Zhuang Fenggan, president of the Chinese Aerodynamics Research Society, told XINHUA that China began its aerodynamics theoretical and experimental research in the 1960s. Chinese scientists have applied their research findings into such fields as aviation, astronautics, weather forecasting, textiles, nuclear science, shipbuilding, marine engineering and water conservancy.

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CSO: 4010/61

NATIONAL DEVELOPMENTS

MUNICIPAL REGULATIONS ON RADIATION PROTECTION BECOMES EFFECTIVE

SK090349 Beijing City Service in Mandarin 1000 GMT 23 Apr 86

[Text] The Beijing municipal provisional regulations radiation protection and control, jointly drawn up by the Municipal Public Health Bureau, the Municipal Public Security Bureau, and the Municipal Scientific Technological Commission, will be put into effect on 1 May.

A responsible comrade of a department concerned stressed: Those units in Beijing which engage in production, application, and marketing of radioisotope, radiant, and other radioactive materials should handle affairs in strict accordance with regulations and actually grasp the safety control work.

Over the past few years, owing to the poor management and systems, the municipality has experienced the loss of radioactive elements [Die Shi Fang She Yuan] and the accident in which radiation operators were irradiated unusually. Therefore, it is necessary to protect and control radiation with the legal system, rather than with general administrative measures.

At the municipal meeting on radiation protection held on 23 April, a responsible comrade of the Municipal Public Health Bureau called on various pertinent units to strictly control radiation in line with the Beijing municipal provisional regulations on radiation protection and control, and to conscientiously follow the license and registration systems. The radiation workers must receive physical check-ups before their employment and must receive regular physical check-ups after they are employed. At the same time, we should attend to the treatment of accidents. Those units which have created disturbances and those who are responsible for accidents should be called to account.

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CSO: 4008/1081

NATIONAL DEVELOPMENTS

CHINESE, JAPANESE SCIENTISTS TO STUDY 'KUROSHIO' CURRENT

OW210208 Beijing XINHUA in English 0153 GMT 21 May 86

["Sino-Japanese Joint Operation To Survey Black Current"--XINHUA headline]

[Text] Shanghai, 21 May (XINHUA)--Chinese and Japanese scientists have begun a 6 to 7 years-long joint survey of "Kuroshio" or black current, according to China's State Oceanic Administration today.

Chinese marine research vessels, Shijian and Xiangyanghong No 9, set off separately from Shanghai and Qingdao yesterday for the 10,000-nautical-mile survey that will cover the East China Sea and western part of the Pacific off the Japanese archipelago.

Japanese vessels were also reported to set off the same day.

Kuroshio is one of the two strongest and most spectacular ocean currents in the world. The other is the Mexican Gulf Stream. Both are known for their warm, highly saline water. The Kuroshio originates east of the Philippines, flows northward between Taiwan and the Ryukyu Islands into the East China Sea and then splits just off the Pacific coast of Japan.

According to scientists, this strong, narrow current has direct impact on the depositing and formation of the sea near China's east coast and Japan's south coast. It also influences the climate, fish resources, fishing grounds, the roving of sewage and sea routes.

The survey would be divided into four stages. During the first stage, 20 items will be conducted in the fields of hydrology, climate, chemistry and biology.

The cooperative research program was arranged by the Chinese and Japanese Government in March last year.

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CSO: 4010/61

NATIONAL DEVELOPMENTS

COMPUTER USE, TECHNOLOGY ON RISE IN PRC PROJECTS

HK040442 Beijing CHINA DAILY in English 4 Jun 86 p 1

[Article by staff reporter Nie Lisheng]

[Text] Computers are no longer confined to scientific research, national defense or other State key engineering projects, but have entered almost every sector of the economy.

Cultural, medical, athletic, meteorological and public security fields are also enjoying their benefits.

More than 20,000 research and exploration projects are now using computers, compared with only several hundred five years ago, according to Li Xianglin, office director of Electronic Development Leading Group under the State Council.

He told a press conference in Beijing yesterday that the number of people working in the computer industry — had jumped four times since 1980 to more than 100,000, not including some 5,000 teachers giving computer classes at primary and secondary schools.

Quite a number of computers can be operated in both English and Chinese, and 10 ethnic minority languages including Tibetan and Mongolian can be processed on computers. But much more headway has been made with the technology of Chinese information, Li said.

Li said that China had spent some \$200 million on importing computers, especially microcomputers. He also admitted that the country had a small stockpile of computers because it had not trained enough people to operate them. The country now has 7,000 computers and 130,000 microcomputers.

Li was briefing reporters on the national computer exhibition in Beijing which opens on Friday and runs until June 30 in celebration of the 30th anniversary of the founding of China's computer industry in 1936.

With computers being used in 19 major trades or professions, Li said, the exhibition would demonstrate China's success to raise product quality and cut production costs through computerization.

In the metallurgical industry for instance, China has transformed 120 industrial furnaces with the introduction of microcomputers and cut energy use by 15 percent, saving 36 million yuan.

The machine-building industry has developed 50 types of computer-controlled machine tools, while China National Petrochemical Corporation saved 260 million yuan in 1985 when it computerized production and management.

Computers have also been used to process data with similar success. The Ministry of Oil Industry has thus cut the cost of verifying 100 million tons of oil reserves from 790 million yuan in 1981 to 320 million in 1984.

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CSO: 4010/1046

NATIONAL DEVELOPMENTS

INVENTORS DONATE MULTI-LANGUAGE COMPUTER SYSTEMS

OW120312 Beijing XINHUA in English 0238 GMT 23 Jun 86

[Text] Beijing, 12 Jun (XINHUA)--The co-inventors of a Chinese-character computer coding method donated two multi-language computer systems to the Tianjin Scientific and Technical Association on Tuesday.

The Li brothers, Li Jinkai and Li Yimin, are teachers at Beijing Teachers University. They have also donated eight computer systems worth 300,000 yuan to the General Office of the State Council, the Everbright Industrial Company, the State Patent Bureau and three other units.

In addition, they have also donated five computer systems worth 100,000 yuan for the development of Chinese-character computer information.

They invented the stroke-coding method for computer processing of Chinese characters after a decade-long effort. With help of the Chinese State Patent Bureau, they obtained the patent right in January 1985 from a British patent bureau.

They earned more than 500,000 yuan through transfer of the patent to three computer companies in Hongkong.

Another of Li Jinkai's inventions for multi-language computer processing won a patent right from the State Patent Bureau.

The 50-year-old inventor told XINHUA that he would use the income from his patent to promote the new process.

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CSO: 4010/1046

NATIONAL DEVELOPMENTS

COMPUTERIZATION PLANNED FOR ENTERPRISES

Two Industries To Test Plan

OW241401 Beijing XINHUA in English 1332 GMT 24 Jun 86

[Text] Beijing, 24 Jun (XINHUA)—The Machinery and Electronics Industries have been selected for the trial use of computerization in Chinese industry, a national meeting was told here today.

In the machinery industry, part of the management work in more than 1,000 enterprises will be micro-computerized in 1986-90, said Lu Dong, deputy head of a leading group under the State Council for boosting the country's electronics industry.

An auxiliary computerized design system will be established for 24 product series in the machinery sector, he added.

Partially computerized information systems will be established in selected key enterprises in the electronics industry, said Lu Dong, who is also minister in charge of the state economic commission.

Another computerized system will be set up for the design of integrated circuits and other major electronic components, he added.

In 1986-90, work will start on computerizing 11 service trades such as posts and telecommunications, state economic information, banking, monitoring and control of power grids, railway transport, weather forecasting, civil aviation and the retrieval of scientific and technical information.

In the next five years, Lu Dong said, computers should be used mainly for transforming China's traditional industries and for the development of high-technology industries.

Speaking of the policy measures for promoting the country's electronics industry, Lu Dong said that the import of items which may be manufactured in China must be strictly controlled. However, he added, imports are permissible for urgently needed items and those which the country cannot produce at present.

Official Discusses Strategy

HK250226 Beijing CHINA DAILY in English 25 Jun 86 p 1

[Article by staff reporter Nie Lisheng]

[Text] China is hoping to witness a computer revolution in the next five years, as the country upgrades industry through the wide application of information technology, especially more adaptable microcomputers and their software.

Special efforts will be made to develop complete computerized management information systems at key large and medium-sized enterprises chosen for trial management modernization or major technical transformation during the Seventh Five-year Plan period, said Lu Dong, head of the State Economic Commission, yesterday.

He told a national conference on computer application that all enterprises in the machine-building and electronic industries were required to experiment with computer-assisted production and management from 1986 to 1990. Both industries are importantly committed to supply equipment to other industries.

The machine-building industry is to partially introduce microcomputers into management at more than 1,000 enterprises, and complete a computer-assisted design system for 24 major electrical machinery products. The total output value of such products is planned to reach 6 billion yuan by 1990.

A total of 29 key electronics plant are aiming to completely modernize their management by setting up computerized information and design systems for such major electronic products as integrated circuits. Some production processes will also be brought under computer control in the next five years.

Lu Dong, who is also vice director of the Electronic Development Leading Group under the State Council, said the State had also worked out plans for large computerized information systems for posts and telecommunications, State economic administration, banking transactions, power network monitoring, the Beijing-Shanghai Railway, weather forecasting and civil aviation.

To promote computer application, Lu said, the construction of all new enterprises in the next five years must include an allocation of funds for computer facilities. In existing enterprises, computers should also have priority in the use of renovation funds. Some 3 to 5 percent of their technical transformation funds should be set aside for computer application.

Preferential arrangements have been made to reduce costs and tax payments for enterprises which are active in the programme.

To support the development of domestically-produced computers, Lu said, those models that can be made in China will not be imported, while those which cannot be produced domestically may be imported only with official approval.

"Through wide application of computers, we intend to provide a market for China's own electronic products," he added.

NATIONAL DEVELOPMENTS

TECHNOLOGY CONTRACT LAW DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 10, 12 Oct 85 p 1

[Edited by Wang Kejian [3769 0344 0313]: "Legislation Is a Guarantee for the Reform of Science and Technology"]

[Text] Not long ago, China held a seminar on the work of science and technology laws. This meeting was convened jointly by the National Science and Technology Commission and the education, science, culture and public health committee of the National People's Congress. (See the article by Yu Desheng [0060 1795 0524] in GUOJIA KEWEI Neibu taolun 45 (1958).) The conference discussed ways to strengthen the construction of legal systems for science and technology and preliminary proposals for a legislative plan for science and technology and discussed and revised "The People's Republic of China Technology Contract Law" (draft). The work of science and technology legislation is an urgent matter. Only by straightening out legislation for the area of science and technology can the proper rights and interests of science and technology personnel as well as the smooth undertaking of reform of the institutions of science and technology be guaranteed.

1. Presently there are more than a few contradictions in the work of science and technology but because there is no law to use as a basis, we are powerless in our desire to resolve them. Manifestations of these contradictions are:

1. The entire concept of the social legal system is hazy and the idea that this law should apply to science and technology enterprises is even more hazy. For this reason, leaders at various levels very seldom consider going through legal channels to resolve various large and collective problems in the activities of science and technology.

2. Presently science and technology law is imperfect. The major manifestations of this shortcoming are: 1) the presence of a large number of legal blank spots. A great number of scientific organizations (such as scientific associations, various scientific meetings, etc.) have no corresponding laws to stipulate their legal status, rights, and obligations and the processes and conditions for obtaining government recognition. There is also a lack of legal stipulations on questions of the nature, responsibilities, rights, duties, legal status, hierarchy, and creation or elimination of research

entities of various types at various levels, such as the Research Institutes of the Chinese Academy of Sciences. The bases of scientific research such as the social mission, status, scholarly freedom, and guarantees of intellectual property rights of scientists as well as the fundamental questions of basic regulations, security measures, registration of results, insurance, methods for the transfer of results, information, publications, instrumentation, and laboratory installation in science and technology research all must have laws to provide regulation. 2) Many laws and statutes promulgated earlier have failed partially or totally due to a change of circumstances with the passage of time. That these laws have not been put in order for a long time now has led to the presence of a great number of ineffective laws mixed into the current law code, creating confusion and weakening the peoples' conception that the law must be obeyed. 3) The present system of science and technology law is not sufficient. For example, China has successively promulgated "Regulations for Recognition Awards in the Natural Sciences," "Regulations for Discovery Recognition Awards," and "Regulations for Recognition Awards for the Advancement of Science and technology." The concerns of these three sets of regulations are largely the same, yet there are not a few differences in the range of recognition awards and other areas. The entire set could well be replaced by a comprehensive set of new regulations.

3. The lack of laws directed at institutional reforms. In the reforms the complaint is often heard: "It is reasonable but not legal." Some people even go to an extreme, believing that so long as something is reasonable it does not matter if it is legal or not. They just go ahead and do it and talk about it later. This illustrates that some laws presently in force have become fetters on reform and that laws need to be established which open the way to reform.

II. In the development of science and technology, like any other enterprise, it is not enough to rely on policies and administrative measures. Such development necessarily depends on legal means. Henceforth the work of making laws for science and technology should begin with these points:

1. There must be specialized structures and working bodies to organize and control the work. First the problems of science and technology legislation must be studied on the basis of the "Resolutions of the Central Committee of the Communist Party of China on Reform of the Science and Technology System" so as to cement the results of systematic reform in science and technology in legal form. Science and technology legislation touches on work units and systems on various fronts and the laws enacted must be separately subordinate to different administrative levels.

2. Work to study this legislation must be encouraged. Science and technology are extremely complex social phenomena. They are also mutually connected with culture, education, and economics and so require comprehensive research. At the same time foreign experience must be drawn upon to engage in comparative study of the totality or of individual questions.

3. We must achieve an overall design and make formulations in turn according to the plan. Because the holes in our science and technology laws and plans are excessive, full reconstruction can easily bring about an approach where the treatment is specific to the ailment and ignores the place of each law in the overall structure. In addition, legislation is extremely practical. For this reason the legal system we design ought not to be purely a logically inferred, conceptual product but rather should largely be a response to real problems.

4. The coordination and harmonization of science and technology legislation with other law should be noted. It is not yet a settled question in scholarly circles whether or not science and technology laws or science laws ought to be drawn up alone as a single branch of legislation. But objectively science and technology definitely possess a set of social relations and so should be regulated by a systematized set of legislation. Some relations in the activities of science and technology are also found in several other areas. To use a single law to regulate relationships with a similar nature and content across many areas is frequently very reasonable.

5. All non-legal documents presently in force should be cleaned up to make them legal. Presently, with regard to a large quantity of documents, reports, and addresses, the implementation has been "to do as one pleases" and for "each to take what he needs." This is a major fear in the establishment of law. These sorts of documents and addresses should be cleaned up and have their reasonable parts incorporated into legal documents so as to legalize them.

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CSO: 4008/2033

NATIONAL DEVELOPMENTS

SHANGHAI ADVANCES IN TECHNOLOGICAL DEVELOPMENT

OW182013 Beijing XINHUA Domestic Service in Chinese 2330 GMT 17 Jun 86

[By reporters Shen Shiwei and Wu Mingfei]

[Excerpts] Shanghai, 18 Jun (XINHUA)--Shanghai, the largest central city of China, is making full use of its favorable conditions of a sound technological foundation and large numbers of technicians to catch up with the advanced world technological level and to speed up the application of new technologies to production. Now a variety of new technologies, such as microelectronics, bioengineering, optical fiber communications, and marine engineering, have been applied to various production fields.

A computer-controlled 256-line automatic telegram transmission system developed by the Shanghai Long Distance Telecommunications Bureau in collaboration with other units has reduced the time required for transmitting a telegram from an average of 37 minutes to less than 3 minutes with a considerably smaller chance of errors. This automatic telegram transmission system has been put to use in Shanghai. Since last March, efforts have also been made to introduce it to other cities in the country. In the meantime, thanks to the joint efforts of scientists and technicians from various quarters, good news about Shanghai's achievement in developing integrated circuits has poured in, unfolding a broad prospect for the development of microelectronics.

During the past few years, six institutions of high learning and scientific research organizations, including the Shanghai Silicate Chemistry Technology Institute of the Chinese Academy of Sciences and the No 23 institute of the Ministry of Electronics Industry, have formed "pairs" with some factories and have thus put to use the major research results they have achieved in the field of optical fiber communications. Work has started to produce various kinds of terminal equipment and photoelectric equipment and parts. Some optical fiber communications systems have been put to use in the city's telephone, electric power, radio and television, public security, and transportation departments. These systems have also been supplied to Tianjin, Nanjing, and other cities.

The municipal government has recently decided to build a high technology Industrial Zone--known as the Caohejing High Technology Industrial Zone--and to develop the production of computers, large-scale integrated circuits, optical fiber communications equipment, and laser equipment. Now construction of a large-scale integrated circuit production project using technology introduced from abroad has already started.

NATIONAL DEVELOPMENTS

DOW TRANSFERS TECHNOLOGY TO YANSHAN PLANT

OW181652 Beijing XINHUA in English 1441 GMT 18 Jun 86

[Text] Hong Kong, 18 Jun (XINHUA)--The U.S.-based Dow Chemical Company has signed a technology-licensing agreement with China for the start-up of a polystyrene plant near Beijing in 1989.

Under the agreement, Dow will provide technology, and help in the design, engineering, and procurement of equipment for the plant, Colin D. Goodchild, president of Dow Chemical Pacific Ltd. said here today.

Located at Yanshan on the outskirts of Beijing, the plant will have an annual capacity of 50,000 metric tons.

The agreement, the second of its kind between Dow and China, was signed here 12 June. The first contract was signed in 1984 for the manufacture of cable shielding tape at a wire and cable plant in Chengdu, southwest China.

The Yanshan plant will use styrene monomer and other raw materials produced in China. Some of the plant technicians and engineers will be trained at Dow's Tsing Yi Polystyrene Plant in Hong Kong.

"The increased polystyrene capacity will greatly benefit China's plastic industry," said Goodchild. "We at Dow view the technology-licensing agreement as an important step in further strengthening our commercial ties with the People's Republic of China."

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CSO: 4010/1048

NATIONAL DEVELOPMENTS

FOREIGN S&T COOPERATION, LEGAL PROTECTIONS DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T]
in Chinese No 10, 12 Oct 85 pp 7-8

[Article by Yang Peilin [2799 0160 3829] of the Shanghai Family Planning
Institute: "Foreign S&T Cooperation Must Have the Protection of Law"]

[Text] Since the 3d Plenum of the 11th National Party Congress, the number of cooperative science and technology projects with foreign countries with which China has agreements with has reached 2,700. The rapid development of the situation not only illustrates the profound public support for the policy of opening to the outside, it also signifies that legal questions concerning science and technology cooperation cannot be regarded as unimportant.

Cooperation is basically a kind of scholarly research activity. With the emergence of an industrial property rights system, the results of cooperative research of an international nature not only comes under the category of technology but also impinges on questions of law. This indicates that the rights and responsibilities stipulated in agreements of cooperation by both sides must attain legal confirmation before they can be implemented and carried out smoothly. Now, with the joint-research regulations of the United Nations World Health Organization as an example, the central components of an international agreement are considered to be:

1. Technological information, exclusive patents, and research results (biology and chemistry ought to be samples of comparable quantity) as well as technological innovations communicated orally which are obtained from research projects subsidized by this agreement must all be freely provided to the World Health Organization or agencies designated by this organization.
2. If research results can be converted into products, technologies, or information which is sold, with an economic gain, this organization has the right to a share of the income in proportion to its contribution based on the agreement.
3. In the event of a dispute over cooperative research, if the two sides are unable to come to an understanding on their own, they must submit to the mediation of a third party which both sides have accepted. If the mediation fails, then the arbitration regulations of the World Chamber of Commerce will resolve the issue.

What counter measures do we have in response to these provisions? This is regrettable because our science and technology legislation is still a blank spot. Many units with 4 or 5 years of international cooperation can only follow general science and technology policies in guiding the implementation of particular cooperation agreements. The Zhang kuan li dai cooperative work is only carried out by improvisation. Some departments have fixed a certain number of regulations on their own but are suffering from inconsistency in the requirements and a lack of authoritativeness and a scientific nature. This has gotten to the point that with the development of joint research and the consequent production of a large set of questions such as patents and proportion of profit from results there is even less of a call for unification. Frequently it is a case of withdrawing from talks before they begin and the absence of any consensus. Some people say: "We can't refuse to talk, but we can't talk about everything." Others say: "The important things don't get talked about." And not a few hold the opinion that in a joint project secrecy questions do not exist. In fact these conditions, where there is no law to rely on, have bred various sorts of dangerous factors which are no help to the smooth implementation of the cooperative projects. One unit which had already signed the above agreement with an international company found itself in the situation where it had difficulty completely making known its participation in national research because of the limits of various regulations. At this point the foreign partner asked: "United Nations joint projects are precisely for the purpose of giving full play to the function of your unit within China. Yet you haven't undertaken even a single national project. How are people to make sense of this?" There was a pharmaceutical cooperative task where due to restrictions by various factors on our side, we were not able to deliver the samples and make headway according to the stipulated time table. The result was that the foreign side reduced its \$150,000 subsidy to \$60,000. Not only this, the foreign partner in a report also said that the leadership of this cooperative task was ineffective, which truly put the cooperating unit in a dilemma. To manage things according to the agreement violated regulations and not to manage them according to the agreement meant that there would be no way to continue the cooperation.

In theory, equal mutual benefits are the motive and goal of joint cooperation. Everyone invests capital and expends labor and no one will be courteous to the point of being unconcerned with patents or not asking about results. Illustrated in practice, many foreign organizations and structures have far richer experience and learning in the area of cooperative research than does China. In the development of cooperation and the administration of various programs they more heavily stress doing things according to the agreements and take the contract regulations as the norm. In this situation, to have people continue to ignore the stipulations in agreements concerning the sharing of results or to cling to the idea of counteracting the past by trusting luck, just discussing superficialities and not discussing substance, is extremely naive. Similarly, the way of doing things where scruples are lost as soon as cooperation is mentioned and where the various units compete to demonstrate their "research strength" to foreign countries also will not do.

In the final analysis, so long as there are only agreements without legal guarantees, some cooperative programs will have a hard time avoiding difficulties in execution or working blindly.

In recent years, China has established "Laws for Economic Cooperation Between the People's Republic of China and Foreign Countries," "Laws for Investment," etc., which have effectively promoted foreign economic cooperation. In the area of science and technology cooperation the various departments also are not without models of accomplishment and methods of efficiency. The problem is how to unify experience and methods according to the spirit of reform and openness and to formulate procedures for serious science and technology cooperation which are in accord with China's situation. This will allow the various kinds of cooperative agreements to cast off restrictive constraints of very different sorts and replace them with signed contracts, implementing them under guarantees with the force of law. According to this approach, all the programs that China carries on independently need not come within the scope of cooperation and all those programs that are cooperative, to the level of entire units (like the Joint Capital Research Institute) will have any contradictions over patents and sharing of results resolved in the spirit of the agreement. What has been learned from 5 years of practice indicates that this is one key to guaranteeing the development of Chinese-foreign science and technology cooperation.

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CSO: 4008/2033

NATIONAL DEVELOPMENTS

SEMINAR ON MEDICAL IMAGING TECHNOLOGY OPENS

OW181310 Beijing XINHUA in English 1204 GMT 18 Jun 86

[Text] Beijing, 18 Jun (XINHUA)--Major hospitals and medical colleges in China's various provinces, municipalities and autonomous regions are now equipped with x-ray computerized tomography machines, thus greatly improving their clinical diagnostic level.

This was disclosed at a seminar on medical imaging technology, sponsored by the Chinese association of medical imaging technology, which opened here today.

Computerized tomography has enabled doctors to obtain accurate diagnostic images of human organs and tissues including the brain, heart, liver and pancreas.

In recent years Chinese scientists have developed a number of items of medical imaging equipment. The Shanghai Medical Electronic Equipment Plant has produced a line-array electronic-scan diagnostic system for examining the brain, liver, gland, gallbladder and other human organs. Beijing's Qinghua University and the Shanghai Medical Meter Factory have jointly developed a duplex ultrasound diagnostic system with a digital-scan converter. The system can produce clearer images of the cardiovascular system, and the speed and direction of blood flow.

During the three-day seminar more than 500 scientists and doctors from across the country will share their experiences related to computerized tomography, ultrasound tomography, nuclear medical imaging technology, medical image processing and medical electronic microscopy.

At today's opening ceremony, vice-president of the Chinese Association of Medical Imaging Technology, Xie Nanzhu, gave a lecture entitled, "New progress in modern medical imaging technology."

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CSO: 4010/1047

NATIONAL DEVELOPMENTS

PUBLIC HEALTH VICE-MINISTER ON TRADITIONAL MEDICINE

OW140054 Beijing XINHUA in English 0046 GMT 14 May 86

[Text] Beijing, 14 May (XINHUA)—China plans to train 60,000 more doctors and pharmacists of traditional Chinese medicine in the 1986-90 period, about three times the total over the past three decades, said Hu Ximing, Vice-Minister of public health.

In an interview with XINHUA, the Vice-Minister said traditional Chinese medicine has particular advantages and is popular among Chinese people, especially the 800 million peasants.

Many developed countries are also trying to develop natural medicines and non-drug therapy as the harmful effects of chemical drugs and chronic and difficult cases that Western medicine can not effectively control become more apparent.

More than 1,000 doctors from 120 countries have come to China to receive training in acupuncture and moxibustion, and other traditional Chinese therapies since the 1970s.

Hu, former doctor of traditional medicine, showed concern about shortage of personnel and medicinal herbs, inadequate facilities and poor management in this field due to negligence in the past.

Chinese leaders Deng Xiaoping and Zhao Ziyang have stressed development of Chinese medicine repeatedly in recent years.

In January this year, the State Council decided to set up a State Administration of Traditional Chinese Medicine.

"This is a milestone in the development of traditional Chinese medicine," Hu said.

In the development of traditional medicine, the Vice-Minister stressed scientific research.

It is necessary to enrich and develop the teaching of and research into traditional medicine with advanced technology and scientific methods," he said.

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CSO: 4010-1048

NATIONAL DEVELOPMENTS

NUMBER OF PRIVATE DOCTORS, DENTISTS INCREASES

HK110328 Beijing CHINA DAILY in English 11 Jun 86 p 3

[Text] The number of private doctors, dentists and nurses has risen to 116,000, the national HEALTH NEWS newspaper said this week.

The paper said the boom of private practitioners in China has eased the pressure on State-run hospitals and clinics which are usually crowded. It has also made medical services more convenient for the people.

Most of the private doctors are in retirement and they specialize in dentistry, orthopaedics, and traditional Chinese medicine. Such clinics are in great demand and they are made within easy reach by the private doctors, the paper said.

The paper called for more flexible policies to encourage more medical veterans to engage in private practicing.

China started to allow retired doctors to open their own businesses in 1980. By 1984, there were 80,000 private doctors across the country. Doctors and nurses in active services were allowed to offer services in their spare time and earnings from such services went entirely to the providers themselves, but deductions were made when public medical apparatus were used.

The HEALTH NEWS said despite the obvious benefits brought about by the private doctors, many government departments in charge of the country's medical system still hold the steadfast belief that it is not necessary to have private doctors since the State-run hospitals and clinics can provide basically every kind of service.

According to experts, the need to allow doctors to practise privately lies in the fact that there is only an average of 2.07 State hospital beds and 1.35 doctors for every 1,000 people in China. This puts heavy pressure on the existing State-run facilities.

Urged by the Ministry of Public Health, big and small cities are simplifying the procedures for private doctors to register. In Shanghai, for example, the city authorities have announced that medical professionals retired from State-owned hospitals would continue to enjoy their retirement benefits after they start private practices.

However, the paper said, the examination of the qualification of the private doctors should be strict in order to protect the interests of the people.

NATIONAL DEVELOPMENTS

DEVELOPMENT STRATEGY FOR TIANJIN'S COLLEGES DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T]
in Chinese No 10, 12 Oct 85 pp 16-18

[Article by Zeng Di [2582 3321] of Nankai University: "A Model for the Year 2000"]

[Text] The level of education is a major index of the economic strength and the standard of science and technology of contemporary nations and regions. In 1977 in the United States for every 10,000 persons there were 523 college students. In 1982 in Tianjin for every 10,000 persons there were 50 college students. The United States had about 10.2 times as many students as Tianjin. Average per-capita income in the United States is \$13,000. For Tianjin average per-capita income is \$1,800. Per-capita income in the United States is about 7.2 times higher than in Tianjin. This illustrates that if the labor productivity of Tianjin is to be raised to the level of the United States, secondary occupational education (including senior middle school) must be increased by at least a factor of three and higher education must be increased at least tenfold. Thus the educational strategy of Tianjin ought to take the present educational levels of the United States as a reference system, striving within this century to attain the average standard of the United States in the early 1980's. This historic mission will be completed in two steps.

I. The first step began in 1984 and will increase annually by 15 percent in 1990. Based on an increase of 16.5 percent in enrollment in general higher education between 1983 and 1984, it seems that the ability of the local administration of Tianjin to sustain this over the coming years is sufficient to accomplish the goal.

This step will require the resolution of several related questions.

The first problem is the question of speed and quality. The quality of Tianjin's local higher educational institutions is rather thin and weak, so there are difficulties with supporting a rate of development that is higher than economic growth. But there exists here also the conditions and possibilities to resolve the problem. The first of these is that there is a higher education teaching corps of 10,000. Second, there are over 200 research institutes, a portion of whose strength can be used to expand higher education. Third, Tianjin is a more developed port city and has broad connections both

abroad and at home. Moreover, Tianjin has the capital, Beijing, very close at hand and there are various sorts of good information channels. The reason that the possibility for rapid development exists is that presently education is emphasized in the strategy for the socialist modernization plan and has received widespread emphasis. The function of science and technology is extremely prominent in its role as corrective remodeler for productive strength in industrial construction and concentration of technologies. This situation makes the expansion of the quantity and the increase in the quality of higher education into objective pressing needs for social and economic development.

The second problem is the educational structure and the question of proportions. The educational structure in Tianjin, viewed from the macroscopic level, has a severe imbalance between the natural and social sciences. Social and economic sciences in particular have been ignored for a long period. The goal of Tianjin's economic strategy is to participate in international competition in finance, trade, technology, and commerce.

The construction of the various disciplines within the natural sciences also requires adjustment. The number of health technicians in Tianjin is the highest in the world. At 0.54 percent of the population this is more than twice as much as in countries with relatively high standards of medical treatment. Higher educational institutional health education is at 9.4 percent, also by proportion the highest region, and is even 25 percent higher than in the Soviet Union where medical education is stressed more than anywhere else. Medical personnel in the Soviet Union constitute 0.32 percent of the population. For this reason, the areas of medical treatment and health education in Tianjin ought to be reduced to appropriate proportions and the standards of higher education in these fields should be raised.

The direction of structural reform in education must serve the strategy of economic development. The total economic strategy of Tianjin is to use completely and energetically the superiority of the city opened by the port to expand the comprehensive processing of imported and exported first-level products. In the chemical, food, electronics, textile, construction, and information industries as well as the service trades, rapid and high-quality increases are sought to bring about an economic structure with commerce, finance, and trade as its principal components. In this, the emphasis naturally will be on the development of the enumerated industries and the disciplines in the areas of commerce, finance, and trade.

The third problem is the question of investing and fund raising. Because the proportionate educational investment in China is pitifully small, at the very low end of over 100 countries, it would be extremely difficult to rely only on domestic investment to close this gap. For this reason, we must raise capital from various areas to set up new universities. In the constitution, higher education is not compulsory, so it is appropriate that students pay tuition. This is also a means through which funds may be supplemented. In the present stage where state, collective, and individual economic sectors coexist, higher education need not be managed entirely by the government alone.

There is no harm in having multiple forms of fund raising to operate schools. The government can provide guidance only on the basis of law and would not intervene in the authority of the school in the rational use and distribution of people, finances, and material. With this problem resolved then the financial avenues for managing education would be broadly opened. Moreover, the widely recruitment of talent to manage education can be done and intelligent investment and the opening up of intellect can begin.

To what proportion should educational investment in Tianjin be revised. This depends at what level the strategic goals of Tianjin's social and economic development are set. If Tianjin wants to attain an advanced level taking the lead in developing the nation in areas of society, economy, and science and technology, then by the beginning of the 1990's we must reach a level of educational investment between 4 and 5 percent of the GNP.

The fourth problem is the question of undergraduate versus professional education. In a highly developed society like the United States, the ratio of undergraduates to professional students is 2 to 1, whereas in a lagging economy such as our own nearly all higher education is undergraduate, which is an unwise policy. The cost of a single 2-year professional graduate is about one-third that of educating a 4-year undergraduate and there is hardly any difference when they get to basic enterprises and engage in technological service for productiveness. This is so because for work in production technologies everyone requires training and the systematic theoretical knowledge possessed by undergraduates is not that useful. Within the next 5 years, Tianjin will at least adjust the ratio of undergraduate to professional students to 3 to 1 or 4 to 1. To complete this task is not at all difficult. It can be done simply by insuring that the present number of undergraduates does not increase while at the same time energetically working out professional study programs. This will foster the potential of the older faculty but without putting excessive added pressure on the schools. As a rule, professional students in the city are day students. In the next few years the major difficulty facing educational expansion will be to keep pace with the basic plan but this method will expand the quantity of graduates, satisfy the urgent needs of industry, and at the same time give consideration to the schools' ability to support the growth.

The fifth problem is the question of the ratio between teaching and administrative staff and students. In Tianjin the ratio of higher education faculty to students is 1 to 3.9 while in most of developed countries it is 1 to 16, with some reaching 1 to 20. Obviously, the burden of Tianjin's teachers is only one-fourth that of these countries. Only by improving the living conditions of teachers can the ability of these teachers to support more students be increased. This implies that to complete the first-step goal it is not necessary to increase the number of teachers but we must implement necessary replacements, including turning teaching assistantship work over to graduate students. There is also the effective method of reducing the staff and worker corps, which would be to socialize a school's logistical service work. Otherwise, increased educational funding could be eaten up by constantly expanding the staff and worker corps so that there could not be more expansion.

The sixth problem is the question of standard versus non-standard education. In China there has been a rapid development of occupational education in recent years. This is an important part of higher education and is a sure course to speed the "intellectualization" of cadres. At present it also is a major supplement to higher education to correct the unreasonable situation of higher education's vertical structure. By the 1990's and after, when secondary education is universal and after higher education has taken a large step forward, occupational education will enter a high-level stage of expansion. Entering into the information age, new knowledge, new technology, and new industries will double in 5 or 6 years and education will always be the foundation although increasingly it will be unable to satisfy the needs of an expanding society and economy. Since the standard of Tianjin's occupational education is uneven and its quality is difficult to test and guarantee, we propose to establish a unified testing committee and repository of test questions. Study can be done broadly but one must pass the test subjects stipulated by the testing committee before receiving a diploma. If there is to be broadly developed occupational education there must also be strict regulation of student status. This is a complementary aspect of a single question. If we are firmly to block the phenomenon of possessing diplomas to "win promotion" then diplomas ought to possess legal seriousness and scientific authority.

II. For the goal of the second step we would do well to select three expansion speeds (i.e., rates of annual increase in students at higher educational institutions from 1990 to 2000 of 10 percent, 15 percent, and 20 percent to see the conditions of the realization of the first step and to implement a "rolling" plan (goals).

We project that by the year 2000, the population of Tianjin will be at least 10 million. If educational development follows the first rate, Tianjin will attain the levels of higher education Japan, West Germany, France, and the East European countries had in the late Nineteen Seventies. If development is according to the third rate the level of higher education in the United States at the end of the 1970's will be attained, and if the expansion follows the second rate, Tianjin could overtake or approach the levels of Japan, West Germany, France, and the various East European countries because the rates of increase of these countries since the 1980's has been lower. The United States has already reached a state of saturation where it has passed the period of increasing quantity and is in the stage of improving quality and expanding scientific research.

The goal of Tianjin's economic strategy is to increase the total output value from 20 billion yuan in 1980 to 100 billion yuan by the year 2000, a fivefold increase. If the expansion of higher education is to proceed in the same proportion, then the 30,000 students of 1980 should increase to 150,000 by the year 2000. The annual rate of growth to achieve this speed of expansion is 8.5 percent. If, for the next 15 years, Tianjin can insure a rate of increase in educational funds of 16 percent, then to attain the general level of higher education the United States had in the late 1970's is entirely possible. This is because the attendance rate of 6 years of elementary

education in Tianjin has already reached 99 percent and for 9 years of primary education it is 76 percent. With a period of 3 or 5 more years, 9 years of primary education can become universal. In order to achieve this aspect of educational growth we must improve school conditions and raise the quality of instruction. The major task of the next 5 years is to expand secondary school attendance (senior middle school) and various kinds of vocational and technical education, to go from the present level of 27 percent to 80 percent to provide the intellectual preparation for a large expansion in universal higher education and vocational higher education in the next decade. For the first 5 years a larger part of the increases in educational funds will be used for expanding secondary education but for the 10 years after that the part for expanding higher education will be the greater share. Because the fundamental thing for education is the future, higher education must do the preparatory work of opening minds and fostering talent for future social and economic expansion. Whether this preparatory work is complete or not will determine the speed and quality of future development. How well-off the Chinese economy will be at the end of this century and whether it surpasses the economic level of industrially developed countries in the 21st century will be determined by the degree of development of education in the next dozen or so years. The history of various countries in the world in the last few decades has shown that the average level of education in a country is in direct proportion to the economic strength of that country. The educational development in various areas in China is uneven but is also in direct proportion to the economic strength of a given area. Presently the level of higher education in Tianjin is 2.7 times the national average and Tianjin's labor productivity is 2.5 times the national average. If Tianjin is to maintain its economic position as the third largest city it can only firmly grasp the two stages outlined above for educational expansion in the next 15 years. Along with implementing the plan for the second stage, in addition to continuing to complete the reform of the six problems of the first stage, the following three problems must also be resolved:

First, Tianjin is a central city open both internally and to the outside. In addition to opening up the intellectual resources of the city itself, attracting outside intellectual resources ought also to be encouraged, especially those from the interior. Intellectual resources differ from material resources in that they become more fruitful the more they are exploited. The development of China's various areas has been uneven. As the relatively advanced coastal cities attract and open up to intellectual resources from the interior, this will speed the development of the coastal cities and can also assist in the exploitation of intellectual resources in the interior. Opening up education will be of limitless benefit to Tianjin.

Second, this stage will serve as preparation for the urgent situation in the expansion of the world economy and in science and technology. The first stage mostly will modify the tendencies and horizontal structure of higher education for the needs of Tianjin itself to insure the various types of talent needed for Tianjin's development. But the point of emphasis for this stage ought to be to foster competitive talent which can participate in the world market economy.

Third, research on the intellectual development and individual guidance of only children must in particular be stressed. This is a great problem related to the success or failure of second-stage education. Moreover, it is a question specific to China in the next few decades. Sociologists, psychologists, and educators must work together diligently to study the educational problems of only children. If it is not done right, it could become a serious obstacle to intellectual development.

12966/12795

CSO: 4008/2033

NATIONAL DEVELOPMENTS

BRIEFS

GUIZHOU ORGANIC GEOCHEMISTRY WORKSHOP—Guiyang, 13 June (XINHUA)—Chinese Organic Geochemistry is at an advanced level, according to a leading European scientist. P.A. Schenck, chairman of the European Society for Organic Geochemistry, has been attending a seven-day workshop which closed today in this capital of south-west China's Guizhou Province. Schenck said that he and other foreign scientists were all impressed by the work of their Chinese colleagues. An example Schenck cited was that the Chinese scientists had been able to analyze and appraise two kinds of compounds—steranoid and terpanoid—which have complicated structures. The workshop was organized by the U.N. Development Program (UNDP), UNESCO and the Geochemistry Institute of the Chinese Academy of Sciences based in Guizhou Province. During the workshop, five foreign scientists and more than 100 Chinese scholars exchanged their latest findings in the area of biomarkers and kerogens, which are of significance for oil prospecting. Altogether, 37 academic papers, including 17 by foreign experts, were read at the workshop. The five foreign scientists and 13 Chinese experts gave lectures. [Text] [Beijing XINHUA IN English 1740 GMT 13 Jun 86 OW] /7051

CONTROL-SYSTEM SOFTWARE PACKAGE DEVELOPED --Beijing, 20 June (XINHUA)—A control system software, the China control systems computer-aided design package, the largest ever achieved in China, has passed state certification test. Developed by more than 100 experts from 17 specialized research institutions and colleges, the package will help to upgrade the analysis and design of the control system and raise its calculating efficiency. Consisting of 19 sub-packages and two base banks, the software package can well function in system identification, mathematical modelling, analysis, design, forecast of the control system. Trial use of some of the sub-packages in the process of the research work has shown satisfying results. A Beijing chemical plant, for example, by using the control system software package, can now calculate the model parameter of the synthetic ethylene acetic acid in a few or dozens of minutes instead of several days previously. Calling it important to the development of the computer industry and control systems, experts said that the newly-developed software package has filled the gap in China's automatic control system calculation and computer-aided software. [Text] [Beijing XINHUA in English 0111 GMT 20 Jun 86 OW] /7051

STATE COUNCIL LIMITS INTEGRATED CIRCUIT IMPORTS--Beijing, 24 Jun (XINHUA)--Today's economic news in brief (2): Imports of integrated circuit limited. The Chinese State Council has decided to limit imports of integrated circuits in a bid to develop China's own products, and the Ministry of Electronics Industry will work out detailed regulations to govern the imports. [Excerpts] [Beijing XINHUA in English 1411 GMT 24 Jun 86 OW] /7051

JOURNALISTS ESTABLISH ENVIRONMENTAL FORUM --A China Environmental Journalists' Forum has been set up in Beijing to organize mass media workers in their effort for environmental protection through publicity. Representing 37 newspapers, periodicals and press agencies, the association will also promote professional cooperation and coordination among media institutions both at home and abroad. It will mobilize government departments and the whole of society to support journalists in their work for environmental protection for the benefit of all mankind. Early last week, the association received a delegation of environmental journalists from the Asia-Pacific Economic and Social Council and exchanged experiences about the media work for environmental protection. [Text] [Beijing CHINA DAILY in English 12 Jun 86 p 3 HK] /7051

LARGEST RADIO TELESCOPE--Beijing, 15 Jun (XINHUA)--China has begun to build a radio astronomical observatory at the Sheshan Station in Shanghai, "Science News" reports. A 25-meter radio telescope, the largest ever in China, will be installed there. The paper disclosed that China will cooperate with Japan, Federal Germany and other countries in using the radio telescope to carry out joint experiments. The 25-meter radio telescope was developed by the Shanghai Observatory and an institute of the Ministry of Electronics Industry. It is used in measuring base line parameters, revolution of the earth, movement of earth plates, seismological studies and in the study of the position and fine structure of radio sources. It has been used to observe the continuous radio spectrum and the OH line of Halley's Comet earlier this year. [Text] [Beijing XINHUA in English 0615 GMT 15 Jun 86 OW] /7051

YUELI CHAIRMAN OF PHARMACOPOEIA COMMITTEE--The Fifth National Pharmacopoeia Committee was inaugurated today in Beijing. The committee is composed of some 150 experts, professors, and engineers from the fields of traditional Chinese and Western medicine, biology, botany, and chemistry. Cui Yueli, minister of public health, was named its chairman. Vice Public Health Minister Chen Minzhang said today that the compilation of the pharmacopoeia will create important conditions for the implementation of the "PRC Pharmaceuticals Control Law." He expressed the wish that the committee members will do their utmost to strengthen the standardization of pharmaceuticals in China and for the implementation of the Pharmaceuticals Control Law. [Excerpts] [Beijing XINHUA Domestic Service in Chinese 1324 GMT 5 May 86 OW] /8918

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Applied Acoustics

ACOUSTIC LEVITATION TECHNIQUE AND ITS APPLICATIONS

Beijing YINGYONG SHENGXUE [APPLIED ACOUSTICS] in Chinese Vol 5 No 2, Apr 86
pp 1-6

[Article by Zhu Zhemin [2612 0772 3046], Institute of Acoustics, Nanjing University]

[Abstract] The acoustic levitation technique is a new, effective experiment means involving steadily levitating a small object within an acoustic field using the acoustic method in order to study mechanical properties related to acoustic waves. In the acoustic levitation technique, this kind of levitation force is mainly provided by the second-order acoustic radiation pressure, non-time-varying. The paper briefly introduces the theoretical fundamentals, experimental setup, and typical and potential applications of the acoustic levitation technique based on the author's work and his related contacts in the United States. One table lists the data of theoretical and experimental values (for sake of comparison) of fundamental frequency. Five figures show an acoustic levitation setup with and without corpuscles, a circuit layout in the modulating radiation pressure method, a fundamental frequency mode with symmetric acoustic axis, and pictures of mode showing an oil droplet. The paper was compiled from a report at the Third All China Applied Acoustics Symposium in November 1984.

REFERENCES:

1. Apfel, R. E., NATURE PHYSICAL SCIENCE, 233-41 (1971), 119.
2. Apfel, R. E., J. ACOUST. SOC. AM., 59-2 (1976), 339.
3. Apfel, R. E. and Harbison, J. P., J. ACOUST. SOC. AM., 57-6 (1975), 1371.
4. Varanasi, U. et al., CHEMISTRY AND PHYSICS OF LIQUIDS, 19 (1977), 179.
5. Apfel, R. E. et al., J. ACOUST. SOC. AM., 62 (1977) Supp., S55.
6. Apfel, R. E., NAVAL RESEARCH REVIEWS, 8 (1978), 30.
7. Trinh, E. and Wang, T. G., J. ACOUST. SOC. AM., 68 (1980), (Si) S45.
8. Lierke, E. G., J. ACOUST. SOC. AM., 60 (1976), S21.
9. Wang, T. G., IEEE Ultrasonic Symposium 1983, 1124.
10. Goosby, S. G. and Marston, P. L., J. ACOUST. SOC. AM., 68 (1980), S30.
11. Beyer, R. T., "Nonlinear Acoustics" Naval Ship Systems Command, Washington, D.C., 1974.
12. Yosioka, K. and Kawasima, Y., ACOUSTICA, 5 (1955), 167.
13. Marston, P. L., J. ACOUST. SOC. AM., 67-1 (1980), 15.
14. Marston, P. L. and Apfel, R. E., J. ACOUST. SOC. AM., 74 (1983), S27.
15. Zhu Zhemin and Apfel, R. E., J. ACOUST. SOC. AM., 74 (1983), S27.

ACOUSTICAL MULTITARGET SYSTEM FOR SYNTHETIC MEASUREMENT OF EXTERIOR TRAJECTORIES

Beijing YINGYONG SHENGXUE [APPLIED ACOUSTICS] in Chinese Vol 5 No 2, Apr 86
pp 15-18

[Article by Yan Zhengxian [0917 2973 6343], Institute of Acoustics, Chinese Academy of Sciences]

[Abstract] This paper reports on a comprehensive test system for exterior trajectories, utilizing the positioning principle of an acoustical target. In the man-machine dialogue, mode testing can be done with a multi-target system or with one of the targets. This is a new, comprehensive analysis system for the exterior-trajectory-performance of light-weapon bullets, providing a new means for exterior trajectory study with the test functions of a single bullet, but with multiple parameters. A group of bullets (generally 20 in number) can be tested for almost all parameters including the center of mass of the bullet involved. The curves thus recorded have a coincidence degree of more than 0.99. The system performance and automation are unsurpassed by any other target trajectory testing systems. One table shows the test accuracy. Four figures show shock waves in the air during the bullets' flight, acoustical positioning, output waveform and signal transformation of transducers with two-bullet fixed firing, and measurement of time differences.

COMPUTER COMPILATION OF TABLES FOR DESIGNING ULTRASONIC VELOCITY TRANSFORMERS
(III)--SIMPLE TORSIONAL TRANSFORMERS

Beijing YINGYONG SHENGXUE [APPLIED ACOUSTICS] in Chinese Vol 5 No 2, Apr 86
pp 22-28, 31

[Article by Yuan Shixun [7086 0013 8113], Guangxi University]

[Abstract] The article discusses torsional transformers: index, quasi-cone, quasi-catenary and step (composed of two sections of equal-length cylinders) types. Also described are theoretical calculation formulas on the main parameters, as well as three computer-compiled (data) design tables with diameter ratios of 1.01 through 7.00, and design equations listed in the fourth table. Two figures show comparative curves of parameters and the variable cross-sectional areas of a torsional circular-variable amplitude rod. From these data, the index and quasi-catenary types have better comprehensive features while the step type has quite a large amplification coefficient and thus is easily machined. The general contents of the article were reported at the 1983 All China Supersonic Power Symposium. The author is grateful to associate professor Wang Jihao [3769 1142 3185] and computer room colleagues for their support. The article was received for publication on 27 February 1984.

70 MHz SURFACE ACOUSTIC WAVE 63 CHIP BY-PHASE CODED DELAY LINE OF M₃₂ SEQUENCE

Beijing YINGYONG SHENGXUE [APPLIED ACOUSTICS] in Chinese Vol 5 No 2, Apr 86
pp 29-30

[Article by Lu Zhongnan [7120 6945 2809]. Yu Jiong [6735 3518] and Li Youzhi [2621 2589 1807] of Laboratory No 2, Institute of Acoustics, Nanjing University]

[Abstract] The article details the successful development of a surface acoustic wave, 63 chip bi-phase coded delay line with center frequency of 70 MHz, a coding rate of 5 M bits/sec, and a coding length of 12.6 ms. The coding contents from the 33rd to 63rd chip is a repetition of the coding sequence from the first to the 31st chip, thus composing an equivalent translation M₃₂ sequence. This coding delay line is developed for a certain signal processing format in realizing fast, precise synchronization of a time clock in a time division multiplex frequency-expansion communication system. Built on an ST quartz substrate, the device exhibits good temperature stability. Furthermore, to sufficiently exploit a series of advantages of the surface acoustic wave (SAW) device, different tuning-matching inductances were used in design while still allowing the insertion loss of the device to have an acceptable magnitude, in practice. As indicated in testing, the main performance indexes (the autocorrelation peak value and side lobe) are relatively close to the theoretical values. Good results were obtained in operations. The synchronization error is up to the 10 ns value while the signal amplitude of the expanded frequency has a variation of 4 dB in closed circuit tests with a coding rate of 5 M bits/sec and the secondary carrier wave of 70 MHz, thus satisfying the requirements in precise ranging. Four figures show the pulse response (of the device), its expanded waveform of reverse-phase point, and correlation waveforms of the first and intermediate code digits. The article was received for publication on 3 December 1984.

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CSO: 4009/74

Applied Lasers

OPTICAL MIXING AND ITS APPLICATION BASED ON SPIN-FLIP TRANSITIONS

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 6 No 2, Apr 86
pp 53-58

[English abstract of article by Wang Weili [3769 1218 4409] of Beijing
University]

[Text] Using a 5.3 μm CO laser pump, a stimulated spin-flip Raman effect in the semiconductor InSb has been observed. Based on this effect, a tunable four-wave mixing process has been developed. Upon measurement of the spin-level splitting g^* factor, the value for x can be calculated in $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$ or other alloy semiconductors.

TAKING HIGH-SPEED PHOTOGRAPHY FOR REAL EXHAUST PLUMES OF ROCKET ENGINE WITH
LASER TRANSIENT F-P INTERFEROMETER

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 6 No 2, Apr 86
pp 59-62

[English abstract of article by He Anzhi [6320 1344 0037], et al., of the
Physics Department, East China Institute of Technology]

[Text] This paper discusses the operational principles of a large aperture
laser transient F-P interferometer. When using it to take high-speed
photography for exhaust plumes of rocket engines, clear interferograms of the
near-field structure of the rocket engine's real exhaust plume are obtained.
The authors have obtained the mach disk location, boundary value and accident
shock of the near-field structure in the exhaust plume from the interferograms.
When compared with theoretical values, real experimental data is provided for
the design of rocket engines and launchers.

PULSE-WIDTH-MODULATED GAS LASER POWER SUPPLY WITHOUT 50 HZ TRANSFORMER

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 6 No 2, Apr 86
pp 69-72

[English abstract of article by Zhou Zhengyi [0719 2973 6146], et al., of
Shanghai Institute of Laser Technology]

[Text] The author has made a constant current pulse-width-modulated gas laser power supply without a 50 Hz transformer which can attain the high current stability accuracy of 0.3 percent (full range). It has the advantages of good adaptability, multi-purpose use, small volume, light weight and is portable.

TUNABLE SINGLE MODE SEMICONDUCTOR LASER WITH EXTERNAL DISPERSIVE CAVITY

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 6 No 2, Apr 86
pp 73-77

[English abstract of article by Zhou Binkun [0719 3521 3824], et al., of the
Department of Radio Electronics, Qinghua University]

[Text] It has been reported that a tunable single mode semiconductor laser with an external dispersive cavity has been made based on experimental projects. Its linewidth is less than 50 MHz. The stable time of the single mode is more than 20 min. The output power is more than 1 mW (influenced by the structure of the heat sink of the solitary diode) and the tunable range is more than 200 Å.

STUDIES OF PHOTOCONDUCTIVITY AND SWITCH PROPERTIES OF AMORPHOUS SILICON
USING NS PULSE LASER

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 6 No 2, Apr 86
pp 78-80

[English abstract of article by Ma Yurong [7456 3768 5554], et al., of the
Department of Physics, University of Science and Technology of China]

[Text] The steady state and transient photoconductivity has been investigated by using an He-Ne laser and a ns pulse laser as excitation sources. The switching effect of amorphous silicon has also been studied for the first step. It has been found that the steady state photoconductivity varies with excitation intensity, showing an exponential law. The rise and decay time of transient photoconductivity is of the order of magnitude of μ s and decreases with an increase in excitation intensity, but is independent of the electric field applied.

9717

CSO: 4009/79

Astronomy

ON THE PROBLEM OF CRITICAL INCLINATION AND COMMENSURABILITY IN THE MOTION
OF ARTIFICIAL SATELLITES

Beijing TIANWEN XUEBAO [ACTA ASTRONOMICA SINICA] in Chinese Vol 27 No 1,
Mar 86 pp 1-8

[English abstract of article by Liu Lin [0491 2651] of the Department of
Astronomy, Nanjing University; and K.A. Innanen of the Physics Department,
York University, Toronto, Ontario, Canada]

[Text] The resonant problem resulting from the critical inclination and
commensurability in the motion of an artificial satellite is discussed.
Considering the non-spherical perturbation of the earth for the averaged
model, the quality of the equilibrium solution and the corresponding libra-
tion region are given. Finally, we compare this solution with the actual
motion of an artificial satellite. We find that the resonance plays a
stabilizing role in the motion and that the luni-solar perturbations have
a significant effect on the orbital resonance of 24-h synchronous satellites.

IMPROVEMENT OF IMAGE QUALITY OF SPHERICAL LENS CORRECTOR FOR CASSEGRAIN TELESCOPE

Beijing TIANWEN XUEBAO [ACTA ASTRONOMICA SINICA] in Chinese Vol 27 No 1, Mar 86 pp 80-84

[English abstract of article by Yi Meiliang [5056 5019 5328], et al., of Nanjing Astronomical Instrument Factory, Chinese Academy of Sciences]

[Text] In a previous work excellent results were obtained by using a spherical lens corrector for the Cassegrain telescope. In the optimization processes, the thicknesses of the lenses and the secondary mirror position were taken as constants.

We think that usable results with much better image quality can be obtained if the thicknesses of the lenses and the secondary mirror position are taken as variables optimizing with other parameters. In this paper an example is given to demonstrate this idea. A spherical 2-lens corrector made of fused quartz for the Ritchey-Chretien (R-C) telescope is selected for comparison. By adding the above-mentioned two type variables, we re-optimize this system, obtaining the expected results. It is obvious that the improvement of the image quality is greater, especially the chromatic difference of the image. We think that this idea (even adding the changing of the tertiary mirror position if it exists in the telescope) may apply to any corrector for various types of telescopes.

For convenience and utility possibilities, two other configurations are enumerated in the tables. The image quality, lens thickness and secondary mirror position are studied.

9717

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Chemistry

GENERAL DATA PROCESSING OF SPECTROPHOTOMETRIC METHOD FOR COORDINATION
NUCLEOPHILIC SYSTEM IN SOLUTION OF MONONUCLEAR COMPLEX

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 12, Dec 85
pp 1145-1150

[English abstract of article by Han Weiping [7281 4850 1456] of Northeast
Petrochemical Institute, Harbin; and Sun Xuezhong [1327 1331 1813], et al.,
of Daqing Petroleum Institute, Daqing]

[Text] An improved data processing method for the coordination nucleophilic
substitution reaction between two kinds of ligands of mononuclear complexes
by spectrophotometric method is proposed. This processing method can be
applied to the visible and ultraviolet regions of MZ_i and ML_j .

Experimental data measured by the UV spectrophotometric method for the
competing system are as follows:

ZnY^{2-}	$\beta_1 = 1.63 \times 10^7$	$\epsilon_1 = 2.21 \times 10^5$ (212 nm)
$FeC_2O_4^+$	$\beta_1 = 2 \times 10^3$	$\epsilon_1 = 2.5 \times 10^4$ (216 nm)
$Fe(C_2O_4)_2^-$	$\beta_2 = 4.5 \times 10^7$	$\epsilon_2 = 5.4 \times 10^4$ (216 nm)

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REFERENCES

- [1] Яценко, К. В., *Докл. АН УССР*, 1980, 1, 2306; 何钟林, 刘祁涛, *化学学报*, 1983, 39, 53.
- [2] 韩维屏, *科学通报*, 1983, 3, 242.
- [3] 韩维屏, *科学通报*, 1983, 1, 28.
- [4] Poulsen, K. G.; Bjerrum, J.; Poulsen, J., *Acta Chem. Scand.*, 1964, 8, 921.
- [5] Sillen, L. G.; Martell, A., "Stability Constants of Metal-Ion Complexes", 2ed, The Chemical Society, London, 1964; Supplement (1), 1971.
- [6] 孙学忠, 姜公和, 鲁怀虎, 汪顺军, 韩维屏, *科学通报*, 1983 (1), 15.

¹⁵N NMR STUDY OF SILATRANES

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 12, Dec 85 pp 1151-1154

[English abstract of article by Zhu Jinchang [2612 2516 2490], et al., of the Institute of Photographic Chemistry, Chinese Academy of Sciences; and Chen Bangqin [7115 6721 2953], et al., of the Institute of Chemistry, Chinese Academy of Sciences]

[Text] Various silatrane compounds were studied by means of ¹⁵N NMR spectroscopy. The quantum chemical calculations of some of the compounds were carried out using CNDO/2 method. The following correlations were obtained: ¹⁵N chemical shifts vary linearly with Taft's polar substituent constants $\sigma^*(s)$ of the substituents R on the silicon atoms, and also with the net electronic densities on the nitrogen atoms. From both experimental and theoretical results it can be concluded that the Si-N dative bonds in a series of silatrane compounds actually exist. (Paper received 15 October 1984.)

REFERENCES

- [1] Воронков. М. Г.; Дьяков. В. М., "Силатраны", Издательство Наука, Москва, 1978.
- [2] Voronkov. M. G., *Pure Appl. Chem.*, 1988, 13, 35.
- [3] Parkanyi. L.; Simon. K.; Nagy. J., *Acta Crystallogr. sectB*, 1974, 30, 2328.
- [4] Parkanyi. L.; Bihatai. L.; Hencsei. P., *Cryst. Struct. Commun.*, 1978, 7, 435.
- [5] Кемме. А. А.; Бзюдакис. Я. Я.; Дьяков. В. М.; Воронков. М. Г., *Журнал структурной химии*, 1978, 16, 914.
- [6] Кемме. А. А.; Бзюдакис. Я. Я.; Пестунович. В. А.; Барышок. В. П.; Воронков. М. Г., *Доклады Академии Наук СССР* 1978, 243, 688.
- [7] 王守道, 胡宁海, *中国科学(B)*, 1983, 7, 595.
- [8] 滕脉坤, 吴治新, 吴观丽, *结构化学*, 1983, 2, 281.
- [9] 王守道, 胡建国, *科学通报*, 1981, 26, 603.
- [10] Harris. B. K.; Jones. J.; Ng. S., *J. Magn. Reson.*, 1978, 30, 521.
- [11] 徐广智, 李二成, 鲁开娟, 吴治新, 吴观丽, 陈夏红, *科学通报*, 1983, 30, 40.
- [12] 方一苇, 胡淑蔚, 吴观丽, 徐梦山, *化学学报*, 1983, 41, 630.
- [13] 王殿勋, 张大仁, 鲁开娟, 吴治新, 吴观丽, *中国科学(B)*, 1983, 26, 875.
- [14] Tacke. B.; Wannagat. U., *Topics in Current Chemistry*, 1979, 84, 16.
- [15] Zhu J. -C.; Wu H. -J.; Jiang L. -J.; Martin. G. J.; Chen B. -Q.; Wu G. -L.; Lai Z. -G., *J. Chim. Phys.*, 1984, 81, 407.
- [16] 朱晋昌, 孙贤育, 伍华菊, 蒋丽金, 陈邦钦, 鲁开娟, 吴观丽, *中国科学(B)*, (待发表).
- [17] Pople. J. A.; Beveridge. D. L., "Approximate Molecular Orbital Theory", McGraw-Hill, London, 1970.
- [18] Newman. M. S. (Ed.), "Steric Effect in Organic Chemistry", Chapt. 18, John Wiley & Sons. Inc., New York, 1966.

STUDIES OF ORGANOSILICON COMPOUNDS WITH BIOLOGICAL ACTIVITY. IV. ON THE 2,2-DISUBSTITUTED-3-ALKYL-1-OXA-3-AZA-2-SILACYCLOHEXEN-4-ONE

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 12, Dec 85 pp 1207-1211

[English abstract of article by Wang Minde [3769 2494 1795], et al., of the Institute of Elemento-organic Chemistry, Nankai University, Tianjin]

[Text] A series of organosilicon compounds, 2,2-disubstituted-3-alkyl-1-oxa-3-aza-2-sila-cyclohexen-4-one, has been synthesized from the reaction of N-alkyl salicylic amide with $R^1R^2SiCl_2$ or $R^1R^2Si(OEt)_2$. According to the spectroscopic evidence, these compounds exist in keto-form in agreement with our previous findings. (Paper received 22 November 1984.)

REFERENCES

- [1] 谢庆兰, 张增佑, 有机化学, 1984, 187.
- [2] Coates, L. V.; Drain, D. J.; Kerridge, K. A.; Macrae, F. J.; Tattersall, K., *J. Pharm. Pharmacol.*, 1957, 9, 855.
- [3] Kralt, T.; Moed, H. D.; Ariens, E. J.; Hendriksen, T. W. J., *Rec. Trav. Chim.*, 1980, 78, 207.
- [4] Tanner, D. W.; Bruice, T. C., *J. Am. Chem. Soc.*, 1967, 89, 6954.
- [5] Morris, L. B., U. S. 3 780 030, 1973.
- [6] Ismail, B. M.; Bessler, B., *J. Organomet. Chem.*, 1968, 13, 253.
- [7] 杨石先, 陈其杰, 王明德, 吴仲, 董贻诚, 中国科学 B 辑, 1984, 6, 496.
- [8] 王明德, 谢庆兰, 张增佑, 廖仁安, 化学学报, 1985, 43, (10)
- [9] Clinton, B. O.; Laskowski, S. C., *J. Am. Chem. Soc.*, 1968, 70, 3135.
- [10] Sheinmann, F., *An Introduction to Spectroscopic Methods for the Identification of Organic Compounds* Vol. 2, Pergamon Press, New York, 1974, p. 47.
- [11] Chamberlain, N. F., *The Practice of NMR Spectroscopy with Spectra-Structure Correlations for Hydrogen-1* Plenum Press, New York, 1974, p. 125.
- [12] 蒋尚信, 沈美霞, 陈美华, 肖若塞, 金瑞珍, 徐光满, 化学学报, 1984, 42, 929.

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CSO: 4009/1048

Electronics

STUDY OF POLYGONAL MICROSTRIP ANTENNAS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 6,
Nov 85 pp 1-4

[English abstract of article by Cai Juliang [2580 5468 5328], et al., of
Shanghai Jiaotong University; and Li Wenxiang [2621 2429 4382] of Shanghai
1051 Research Institute]

[Text] A solution to the characteristic parameters of polygonal microstrip
antennas is investigated by the conformal outermapping method. The outside
area parameters of a polygonal microstrip antenna are transformed into
the corresponding ones of a circular microstrip antenna first, then trans-
formed inversely into the boundary values of a polygonal antenna. Thus the
solution of polygonal microstrip antennas is obtained. The theoretical and
experimental results are in agreement. (Paper received in October 1984;
finalized in May 1985.)

REFERENCES

- [1] K. R. Carver: and E. L. Coffey: Theoretical Investigation of the Microstrip Antenna, PT-00929, Physical Science Laboratory, New Mexico State Univ., Jan. 1979.
- [2] H. D. Weinschel: A Cylindrical array of circularly polarized microstrip antennas, IEEE AP-S Int. Symp. Digest, 1975, pp.177-180.
- [3] Cao Ju-Liang (曹菊良): Radiation field of tapered slotline antenna, IEEE AP-S Int. Symp. Digest, 1984, pp.90-93.
- [4] N. G. Alexopoulos et al: Radiation by microstrip patches, IEEE AP-S Int. Symp. Digest, 1979.
- [5] R. E. Collin, F. J. Zucker: Antenna Theory, Part 1, McGraw Hill Book Co., N. Y., 1960.
- [6] K. R. Carver, J. W. Mink: Microstrip antenna technology, IEEE Trans., Vol. AP-29, pp.2-24, 1981.
- [7] P. K. Agrawal, M. C. Bailey: An analysis technique for microstrip antenna, IEEE Trans., Vol. AP-25, pp.756-759, 1977.
- [8] S. A. Long et al.: Theory of the circular-disk printed-circuit antenna, Proc. IEE, Vol. 125, pp.925-928, 1978.
- [9] A. G. Derneryd: Analysis of the microstrip disk antenna element, IEEE Trans., Vol. AP-27, pp.660-664, 1979.
- [10] K. C. Gupta, et al.: Microstrip Lines and Slotline, Dedham, Mass. Artech House, 1979, Chapter 2.
- [11] T. C. Edwards, R. P. Owens: 2-18GHz dispersion measurements on 10-100 Ohm microstrip line on sapphire, IEEE Trans, Vol. MTT-24, pp.506-513, 1976.
- [12] E. H. Newman, P. Tulyathan: Analysis of microstrip antenna using moment methods, IEEE Trans., Vol. AP-29, pp.47-53, 1981.

H-ALGORITHM AND ITS VALIDITY

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 6, Nov 85
pp 5-12

[English abstract of article by Ruan Genhong [7086 2704 7703], et al., of
Fudan University, Shanghai]

[Text] The H-algorithm for test generation of asynchronous circuits is discussed and its validity is proved. A program HALG based on the H-algorithm is developed on a PDP-11/23 computer, and test sequences are generated for some circuits. The results are consistent with the theoretical analysis. (Paper received in March 1984; finalized in May 1985.)

REFERENCES

- [1] 阮根鸿: 异步时序电路测试生成法——H算法, 电子学报, No.1, pp.49—57, 1983.
- [2] 阮根鸿: 六值模拟, 电子学报, No.2, pp.24—31, 1981.
- [3] J. S. Jephson et al.: Three-value computer design verification system. IBM system Journal, Vol.8, No.3, pp.179—189, 1969.
- [4] C. W. Cha et al.: 9-V algorithm for test pattern generation of combinational digital circuits, IEEE Trans., Vol. C-27, pp.193—200, 1978.

FAST DIAGNOSIS ALGORITHM FOR MULTIPLE FAULTS IN PARITY CHECK CIRCUITS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 6, Nov 85
pp 19-25

[English abstract of article by Xu Xingning [1776 2502 1337] of the Beijing
Institute of Posts and Telecommunications]

[Text] A simple and efficient algorithm for locating multiple faults in parity check circuits is presented. It is based on a new concept called "Minority Bit," and the fault location test set so obtained is optimal. The length of the test sequence is equal to the number of primary inputs plus one. The implementation of automatically generating the optimal test set and quickly locating all the faults is also discussed. (Paper received in October 1984; finalized in February 1985.)

REFERENCES

- [1] 王尔乾, 中大规模集成电路, 国防工业出版社, 1981.
- [2] D. C. Bossen, D. L. Ostapko and A. M. Patel: Optimum Test Patterns for Parity Networks, Proc. Fall Joint Comput. Conf., 1970.
- [3] Se June Hong and D. L. Ostapko: A Simple Procedure to Generate Optimum Test Patterns for Parity Logic Networks, IEEE Trans., Vol. C-30, No.5, May, 1981.
- [4] Xingning Xu and E. J. McCluskey: Test Generation and Fault Diagnosis for Multiple Faults in Combinational Circuits, Digest, FTCS-13, Milano, Italy, June, 1983.

ACTIVE FILTER USING OPERATIONAL AMPLIFIER POLE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 6, Nov 85 pp 26-30

[English abstract of article by Peng Shuizhen [1756 3055 6297] of Chengdu Institute of Radio Engineering, Sichuan]

[Text] A new active filter circuit with one operational amplifier, one capacitor and several resistors is presented. The operational amplifier pole is utilized. The circuit can fulfill the second-order lowpass, highpass, bandpass, band-stop and allpass functions. As a band-stop filter, not only can the ω_0 and Q be adjusted independently, but the band-stop attenuation can also be adjusted. Design examples and experimental results are given. (Paper received in June 1984; finalized in November 1984.)

REFERENCES

- [1] A.M. Soliman, M. Fawzy: Some partially active R filter circuits, The Radio and Electronic Engineer, Vol. 49, No. 11, pp. 587-590, Nov. 1979.
- [2] 彭水贞: 有源R带阻滤波器, 电子学报, Vol-10, No. 1, pp. 84-88, 1982.
- [3] M.S. Ghausi, K.R. Laker: Modern Filter Design: Active RC and Switched Capacitor, Prentice-Hall, Inc., p.264, 1981.

LIFETIME LIMITATION OF FRONT-ILLUMINATED EBS-CCD

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 6, Nov 85
pp 54-57

[English abstract of article by Chen Zhongmou [7115 6988 6180], et al., of
Zhongshan Institute of Electronics, Nanjing]

[Text] Based on fundamental research into the electron irradiation degradation mechanism of the front-illuminated EBS-CCD, different factors affecting its lifetime limitations are analyzed. Several practical ways to increase the lifetime are given. Experimental results are in good agreement with theoretical predictions. (Paper received in February 1984; finalized in September 1984.)

REFERENCES

- [1] J. Cheng et al.: AD A062663.
- [2] 陈仲谋, 张吉星: 电子科学, No. 3, p. 45, 1982.
- [3] J. M. Aitken, D. R. Young: J. Appl. Phys., Vol. 47, No. 3-4, p. 1196, 1978.
- [4] C. W. Gwyn: J. Appl. Phys., Vol. 40, No. 12, p. 4886, 1969.
- [5] 江丕雄等: 场效应晶体管及其集成电路, 国防工业出版社, 1974年.
- [6] C. P. Chang: IEEE Trans., Vol. NS-23, p. 1639, 1976.
- [7] C. P. Chang: IEEE Trans., Vol. NS-24, p. 2190, 1977.
- [8] M. S. Cohen, J. S. Moore: J. Appl. Phys., Vol. 45, No. 12, 1 p. 5335, 1974.
- [9] R. L. Gordan: Appl. Optics, Vol. 15, No. 8, p. 1909, 1976.

COMPUTER SIMULATION FOR PROBLEM OF FREQUENCY STABILITY IN MODERN ELECTRONIC SYSTEMS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 6, Nov 85 pp 58-64

[English abstract of article by Guo Yanying [6753 5888 3853] of Beijing Institute of Radio Metrology and Measurements]

[Text] The Monte-Carlo computer simulation is presented in solving the problem of frequency stability in modern electronic systems. Its first key procedure is generating a high quality random sequence simulating the oscillator phase noise, followed by calculation of the response of the system (mathematical model) with this random sequence on the computer. After that, the required statistical estimation can be obtained. The method for designing random sequences is discussed in detail. Finally, two examples--synthetic aperture radar and Doppler velocity measuring system--are given to clarify the realization of computer simulation and illustrate its versatility. (Paper received in June 1984; finalized in November 1984.)

REFERENCES

- [1] 郭衍堂: 宇航学报, 1981年第4期, 第11页。
- [2] 郭衍堂等: 空间跟踪和通信地面发射机系统设计, 第一章, 国防工业出版社(即将出版)。
- [3] D. E. Kauth: The Art of Computer Programming, Vol. 2, p. 78, McGraw-Hill, New York, 1974.
- [4] 冯康: 数值计算方法, 国防工业出版社, 1978年。
- [5] 刘宜伦等: 网络综合理论, 人民邮电出版社, 1982年。
- [6] E. S. Kuh: Principles of Circuit Synthesis, McGraw-Hill, New York, 1959.
- [7] C. A. Green: IRE Trans., Vol. MIL-8, p. 130, April, 1962.

ADJOINT-NETWORK METHOD FOR INCREMENTAL ANALYSIS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 6, Nov 85 pp 72-79

[English abstract of article by Ling Xieting [0407 3610 0080] of Fudan University, Shanghai]

[Text] The circuit tolerance design and fault analysis usually demand the knowledge of circuit properties while the elements are getting incremental changes. The adjoint-network method may give differential sensitivities efficiently, but it cannot be used in incremental situations and nonlinear circuits directly. The extension of this method is discussed. (Paper received in May 1984; finalized in January 1985.)

REFERENCES

- [1] H. W. Bode: Network Analysis and Feedback Amplifier Design, D. Van Nostrand Co. Inc., Princeton, N. J., 1945.
- [2] B. J. Karafin: BSTJ, Vol. 50, p. 1225, 1971.
- [3] S. W. Director, G. D. Hachtel: IEEE Trans., Vol. CAS-24, No. 7, p. 363, 1977.
- [4] 凌贤亭, 潘明德: 电路最优化中心设计的一个新算法, 复旦大学学报(自然科学版), 第21卷, 第3期, 第307页, 1982年.
- [5] S. Skelboe: IEEE Trans., Vol. CAS-26, p. 874, 1979.
- [6] T. N. Trick, C. J. Alajajian: Fault analysis of analog circuits, Proc. 20th Midwest Symposium on Circuits and Systems, p. 211, 1977.
- [7] Z. F. Huang, C. S. Lin, R. Lin: Node-fault diagnosis and design of testability, 20th IEEE Conference on Decision and Control, p. 1037, 1981.
- [8] R. Lin: Analog fault diagnosis: A new circuit theory, Proc. 1983 IEEE Int. Symp. on Circuits and Systems, p. 931.
- [9] 凌贤亭, 非线性电路的故障分析, 电子学报, No.1, p. 70, 1981.
- [10] L. O. Chua, P. M. Lin: Computer Aided Analysis of Electronic Circuits, Pentice-Hall.
- [11] G. C. Temes: Efficient methods of fault simulation, Proc. 20th Midwest Symp. on Circuits and Systems, part I, p.191, 1977.
- [12] S. R. Parker: Sensitivity, old questions, some new answer, IEEE Trans., Vol. CT-18, p.27, 1971.
- [13] 凌贤亭, 模拟电路中有限故障数的预测-判定分析方法, 电子学报, No.3, p.37, 1982.
- [14] T. N. Trick, Y. Li: Proc. 1983 IEEE Int. Symp. on Circuit and Systems, p. 1098.

DISTRIBUTION FUNCTION OF SIGNAL-TO-NOISE RATIOS FOR NON-EQUAL MEDIAN SIGNAL
PREDETECTION OPTIMUM DIVERSITY COMBINING

Beijing, DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 6, Nov 85
pp 91-99

[English abstract of article by Luo Zhengbin [7482 2973 1755] of the
Shijiazhuang Communication Laboratories, Hebei]

[Text] The expressions of probability density and distribution functions of
signal-to-noise ratios for non-equal median signal predetection optimum
diversity combining are given and some computing results are also presented.
(paper received in June 1984; finalized in December 1984.)

REFERENCES

- [1] D. G. Brennan: Linear diversity combining techniques, PIRE, No. 8, pp. 1075~1102, 1959.
- [2] W. B. Davenport, Jr. and W. L. Root: Introduction to Random Signals and Noise, McGraw-Hill, New York, 1958.
- [3] André Angot. 陆志刚等译校, 电工电信工程师数学(上册), 人民邮电出版社, 1979年。

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Optics

SURFACE-ENHANCED RAMAN SPECTRA OF O-PHENANTHROLINE, 2, 2'-BIPYRIDINE AND THEIR COMPLEX IONS ADSORBED ON SILVER COLLOID

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 4, Apr 86
pp 298-306

[English abstract of article by Zhang Chunping [1728 2504 1627], et al., of
the Department of Physics, Nankai University, Tianjin]

[Text] SERS from O-phenanthroline, 2, 2'-bipyridine and their complex ions adsorbed on colloidal silver particles have been observed for the first time. The results provide experimental evidence for the opinion that the 200 cm^{-1} band is related to the N-Ag bond vibration. Comparisons between Raman spectra of the molecules and those of their complexes are made, and some new phenomena are found. Combined with other experimental results (electron microscope photograph, transmission spectra), analyses and explanations are given for these phenomena.

SPECTROSCOPIC PARAMETERS OF Er^{3+} CRYSTALS CALCULATED BY JUDD-OFELT THEORY

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 4, Apr 86
pp 307-313

[English abstract of article by Wang Qingyuan [3769 1987 0337], et al., of
Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Text] In this paper we report the results of spectroscopic intensity parameters of Er^{3+} in YAG:Er^{3+} single crystals. By using absorption spectra and Judd-Ofelt theory the experimental and theoretical oscillator strengths have been calculated. The rms deviation is only 1.9×10^{-7} . Based on a least-square fit between the experimental and theoretical oscillator strengths, the intensity parameters have been determined. The results are $\Omega_2 = 0.19 \times 10^{-20} \text{ cm}^2$; $\Omega_4 = 1.68 \times 10^{-20} \text{ cm}^2$; $\Omega_6 = 0.62 \times 10^{-20} \text{ cm}^2$. We then calculated the probabilities of the induced electric and magnetic dipole spontaneous radiative transitions radiative lifetimes, high oscillator strengths and branching ratios. The fluorescence spectra of Er^{3+} in YAG:Er^{3+} crystals were shown to be in the $0.3 \mu\text{m} \sim 2.0 \mu\text{m}$ wave length range.

MODULATED PHOTOELECTRIC SPONTANEOUS MAGNETIC FIELD IN A LASER PLASMA

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 4, Apr 86
pp 314-319

[English abstract of article by Zhu Shitong [2612 5535 6639] of Shanghai
Institute of Optics and Fine Mechanics, Chinese Academy of Sciences; SHEN Wenda
[3088 2429 6671] of the Department of Physics, Shanghai University of Science
and Technology]

[Text] The spontaneous magnetic field associated with photoelectric effects
in a laser plasma is studied. The analytic solution for the spontaneous
magnetic field temporarily and spatially modulated under the oblique
incidence of s-polarized light into a static isothermal plasma is obtained.

STUDY OF A RING DYE LASER WITH COLLIDING PULSE MODE-LOCKING

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 4, Apr 86
pp 320-325

[English abstract of article by Wang Qingyue [3769 3237 2588], et al., of
the Department of Precision Instrument Engineering, Tianjin University]

[Text] This paper presents results of a study of a ring dye laser which is
colliding pulse mode-locked. The relationship between the concentration of
DODCI, pumping power and pulse width is summarized here. A nearly transform-
limit pulse width of 90 fs has been obtained.

ANALYSIS OF A QUASI-CW PUMPED INTRACAVITY FREQUENCY DOUBLING YAG LASER AND ITS THERMAL EFFECT

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 4, Apr 86 pp 326-331

[English abstract of article by Yao Jianquan [1202 1696 6898], et al., of the Department of Precision Instrument Engineering, Tianjin University]

[Text] From the theory of SHG of Gaussian-like beams, we come to the conclusion that the power of the second-harmonic wave is approximately proportional to the square of the fundamental wave power for frequency doubling of Gaussian-like beams with high conversion efficiencies. Based on this, a new intracavity frequency doubling scheme of a mixing-mode beam, i.e., quasi-CW pumping, is proposed. By using such a scheme, the output power can be increased by a factor of two, a fact that has been proven by theory and experiments. From the thermal conduction equation, it has been found that the beam propagation parameter through a YAG rod under quasi-CW pumping is 22 percent lower than that under CW pumping. If other factors are taken into account, the decrease will become 30 percent. By experimental measurements, we find that the thermal focal length is increased and the divergence angle is decreased, as predicted by theory.

SINGLE LONGITUDINAL MODE CHARACTERISTICS OF SHORT-COUPLED-CAVITY (SCC)
SEMICONDUCTOR LASERS

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 4, Apr 86
pp 332-338

[English abstract of article by Zhou Bingkun [0719 3521 3824], et al., of
the Department of Radio Electronics, Qinghua University, Beijing]

[Text] By introducing an additional loss parameter for the description of SCC and developing a model of modified multimode rate equations, the mode selection mechanism and characteristics of SCC semiconductor lasers have been investigated theoretically. It is found that an antireflection coating on the end facet of a laser diode is necessary for high-quality single longitudinal mode operation. Based on the theoretical results, a new type of miniature SCC laser has been constructed and demonstrated. Single mode outputs with 35-40 dB side mode suppression ratios have been obtained under CW and 150 MHz modulation conditions.

THEORY OF LASER BEAM DISPLACEMENT IN TURBULENT ATMOSPHERE

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 4, Apr 86
pp 373-380

[English abstract of article by Zhang Yixin [1728 6654 2450], et al., of
Anhui Institute of Optics and Fine Mechanics, Chinese Academy of Sciences,
Hefei]

[Text] The displacement of a spatially partial coherent light beam propagating through the turbulent atmosphere has been studied by assuming Gaussian distribution of the wave complex amplitude. The formula for the beam displacement was obtained, and it agrees with experimental data in both weak and strong intensity fluctuation regions.

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CSO: 4009/78

Physics

HEAVY-FERMION SYSTEM AND ITS SUPERCONDUCTIVITY

Beijing WULI [PHYSICS] in Chinese Vol 15 No 1, Jan 86 pp 7-9, 60

[Article by Zhang Liyuan [4545 4539 3293], Department of Physics, Beijing University]

[Abstract] Since the discovery of superconductivity in the heavy-fermion system $\text{CeCu}_2\text{SiO}_2$ in 1979 by F. Steglich et al. (West Germany), up to now three of the eight discovered heavy-fermion systems have been shown to exhibit superconductivity characteristics. Experimental physicists in a number of countries paid great interest to the heavy-fermion system and its superconductivity, as new research subjects are being proposed: why do electrons of the fermion system have such a large effective mass? Which superconductivity characteristics differ from those propounded in the BCS theory? Is there any new superconductivity mechanism? At present, there are two views as to the theory. One view holds that the fundamental regime of BCS superconductivity is still valid. Another view holds that the superconductivity feature of the heavy-fermion system is similar to the superfluid state of ^3He in its A and B phases, since the electron pairing spin is in the triplet state with total spin equal to 1. Further intensive experiments and theoretical research are required. Two tables show the following parameters of heavy-fermion systems: interatomic distance, magnetic susceptibility and specific heat of electrons. Three figures show relationships between the functions of specific heat and temperature, as well as the apparent inconsistency between electron specific heat and the results of the BCS theory when CeCu_2Si_2 and UBe_{13} are in the superconductivity state.

10424/9190
CSO: 4009/61

LIQUID CRYSTAL COLOR DISPLAY

Beijing WULI [PHYSICS] in Chinese Vol 15 No 1, Jan 86 pp 43-47, 19

[Article by Hong Xijun [3163 3356 0689], Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences]

[Abstract] In the 1970's, LCD (liquid crystal displays) developed rapidly due to their unique operational features of low voltage and low power consumption; in particular, the TN field effect monochrome display has been widely commercialized. Like the monochrome display, the liquid color display employs variation of arrangement in liquid crystal molecules (after an electric field is imposed), thus changing the optical characteristics of the liquid crystal container. The GH type color display with the dichroic mode produces a unique, sharp color with high brightness and wide visual angle; thus, research on GH color displays is the most active. Some problems remain to be solved before its commercialization: positive display, matrix display and extended service life of these GH type devices. The article presents the operating principle and the related problems of liquid crystal color displays with emphasis on the dichroic mode. It is predicted that there will be faster development in applications of color LCD in automation instruments, motor vehicles, industrial equipment and consumer goods with the development of better liquid crystals and dyes as well as the use of new techniques. Liquid crystal television will be commercialized with a higher performance-to-price ratio, and in portable information systems. One table shows the operational mode and characteristics of the GH type in its electrooptical effect. Four figures show the absorption characteristics of positive and negative type dyes, the operating principle of the GH type color display, positive-type display GH container, and phase-change Gh type display.

10424/9190
CSO; 4009/61

ION MIXING TO PRODUCE AMORPHOUS ALLOY THIN FILMS

Beijing WULI [PHYSICS] in Chinese Vol 15 No 2, Feb 86 pp 91-96

[Article by Liu Baixin [2692 4102 2450] and Ma En [7456 1869] of the Department of Engineering Physics, Qinghua University]

[Abstract] This article presents the ion beam method (blending of ion migration and ion beam) as a new, unique method, stressing the experimental results and rules reached in recent years by the authors and their research team on ion mixing synthesis of amorphous alloys. As proposed by the authors, an equilibrium phase diagram is used to predict rules and models for the formation of amorphous alloys by ion beam mixing. The article also comprehensively introduces and evaluates research results in other countries on this subject. Two tables list the binary (metal) systems studied and the amorphous alloys formed, including more than 10 binary metal systems studied by the authors and their research team. The measured crystallization temperatures are also given in one of the tables for some of the amorphous alloys produced. Three figures show a typical electron diffraction picture of Ni-Mo amorphous alloy, a formation diagram for certain amorphous alloys, and an alloy phase formation diagram during ion beam mixing corresponding to a typical equilibrium phase diagram. For the first time, the authors produced amorphous Mo-Ru superconducting thin films (with quite good superconductivity characteristics) in which third metals were not added. With their magneto-optical features, these amorphous films can be used in fabricating optical data storage media. Therefore, the authors selected magnetic materials as Gd, Fe, Co and Tb, among other metals, to be combined into binary or even multiple metals in order to gain the advantages of blending into small but controllable quantities of amorphous thin films with several constituents, after blending experiments.

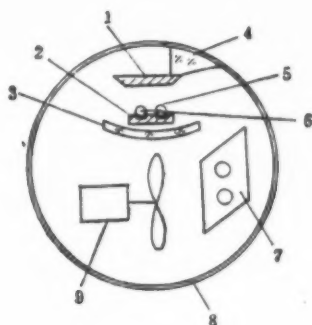
A MEDIUM POWER NONHELIUM LONG LIFE-SPAN TEACO₂ LASER

Beijing WULI [PHYSICS] in Chinese Vol 15 No 2, Feb 86 pp 105-106

[Article by Lu Huibin [0712 1920 6333], Zhou Yueliang [0719 1471 0081], Cui Daju [1508 1129 1788], Guo Shuping [6753 2579 1627] and Hou Jianhua [0186 1696 5478] of the Institute of Physics, Chinese Academy of Sciences]

[Abstract] The TEACO₂ laser has important applications in laser chemistry, laser isolation of isotopes, laser physics and national defense, among other fields. The authors reported on the nonhelium long service-life repetition

frequency TEACO₂ laser. In a number of research areas, relatively high values of average power and repetition frequency are required in a laser; therefore, the authors developed the TEACO₂ laser with intermediate (average) power. In a single operating session, the laser output energy is 10 J, with an average power of more than 80 W. When the relative humidity is below 85 percent, the laser is capable of maintaining nonhelium continuous extended-service steady operation for a repetition frequency within the range between a single operation and 30 operations per second. The profile of the laser structure is as follows:



Key:

- | | |
|-----------------------|-----------------------------|
| 1. Anode | 6. Pre-ionization electrode |
| 2. Cathode | 7. Water cooler |
| 3. Lower stream guide | 8. Outer shell |
| 4. Upper stream guide | 9. Blower fan |
| 5. Pressure plate | |

Two other figures show the relationship between laser energy and voltage, and the waveform of laser pulses when CO₂:N₂=20:1.

DESIGN AND APPLICATION FOR FORCED-VIBRATION PENDULUM WITH WIDE FREQUENCY RANGE FOR INTERNAL FRICTION MEASUREMENT

Beijing WULI [PHYSICS] in Chinese Vol 15 No 2, Feb 86 pp 109-110

[Article by Wen Yiting [2429 0076 3060], Wang Litian [3769 0500 3944] and Du Jiaju [2629 1367 7467] of Institute of Solid Physics, Chinese Academy of Sciences]

[Abstract] For a long time, the low-frequency torsional pendulum has been extensively applied in internal friction studies. In this arrangement, the vibration amplitude and frequency of a vibration system (during free attenuation) are measured. This method has certain limitations: there will be a large error when the internal friction is high; and within the operating frequency range of the torsional pendulum, the temperature may rise to a high value in

some relaxation process--thus the configuration of the test specimen will undergo changes. As early as the 1940's, the forced-vibration torsional pendulum was further developed in the mid-1970's. This method directly measures the difference in phase angle in which strain lags behind the stress. The article presents a frequency forced-vibration pendulum capable of measuring the internal friction and the modulus of elasticity at the extremely low frequency of 10^{-3} Hz with a relatively wide frequency range between 10^{-3} and 5 Hz. Four figures show a model of a vibration system and its stress-strain curves, an experimental layout, photo-electric measurement of angular displacement, and temperature spectra of internal friction peaks of crystal boundary. The authors are grateful to the following individuals: professor Ge Tingsui [5514 0080 3606] for his advice; Xie Cunyi [6200 1317 3015] and Chen Hui [7115 2547] for taking part in some of the experiments; and Gu Chunhui [7537 2504 2547] and his colleagues at the internal friction research team for their assistance.

OPTICAL SOLITON AND FIBER COMMUNICATION

Beijing WULI [PHYSICS] in Chinese Vol 15 No 2, Feb 86 pp 111-116

[Article by Dong Xiaoyi [5516 1321 5030], Institute of Modern Optics, Nankai University]

[Abstract] Liberally interpreted, a soliton is a kind of wave whose energy is confined to a limited range while propagating at a certain velocity. The optical soliton can be interpreted as follows: when a coherent optical pulse passes through a medium, its front part acts and excites the medium while its rear part is acted upon by the excited medium with a gain. The energy loss in the front part is equal to the energy gain in the rear part. Thus, there is no energy loss for the optical pulse. This is the optical soliton phenomenon. The optical soliton makes possible a fantastic capacity in optical fiber communication, since Mollenauer et al. of the Bell Laboratories developed for the first time, in 1984, an optical soliton laser capable of more than 10 billion bits per second of transmission speed in a 75 km optical-fiber circuit. This transmission speed is higher by several magnitudes over the best, modern optical fiber communication. The article presents the propagation features of coherent optical pulses, nonlinear effect and automatic phase adjustment of optical fiber, operating equations of the optical soliton, and optical soliton laser shown in one of six figures. Five other figures show input and output pulses, widening or narrowing of chirp optical pulses while passing through a dispersive medium, characteristic curves of the best commercially available single-mode optical fiber, narrowing of optical pulses (with positive chirp) while passing through an optical fiber, and propagation of a pulse envelope outline with and without distortion.

10424/12859
CSO: 4009/77

RENORMALIZED STRONG TURBULENCE THEORY FOR LOW-FREQUENCY MAGNETIC FIELD AND
ION ACOUSTIC WAVE EXCITED BY HIGH-FREQUENCY WAVE

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 3, Mar 86
pp 283-299

[English abstract of article by He Xiantu [6320 6343 0960] of the Institute
of Applied Physics and Computational Mathematics, Beijing]

[Text] In this paper the renormalized turbulence theory for the low-frequency magnetic field and the ion acoustic wave in high temperature plasma is developed in order to improve the usual weak nonlinear approach. From Vlasov-Maxwell equations, the coupled renormalized equations of the high and low frequency propagator, with the "most divergence" and "secondary divergence" effects included, are derived in the Fourier representation. Thus, we obtain the coupled relation of the renormalized particle distribution function and a field for high and low frequency oscillation.

Under the "most divergence" renormalization approximation, the propagator equations for high and low frequency are solved. Expanding to the order of v_e , the ratio of the energy density of the high frequency turbulence field to the thermal energy density of the plasma particle, the approximate solutions for the propagator and the expressions for the renormalized dielectric function are obtained. Then, by performing a Fourier inverse transformation, the renormalized strong turbulence equations are derived in the space-time representation.

Finally, as an example showing the renormalized effects under one-dimensional and stationary approximations, the analytical form for the soliton is solved.

DENSITY PROFILE STEEPENING DUE TO LASER RADIATION IN MAGNETIZED INHOMOGENEOUS PLASMA

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 3, Mar 86
pp 311-318

[English abstract of article by Xu Zhizhan [1776 5267 1455], et al., of
Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] The effects of a self-generated magnetic field on the density profile modification in laser-plasma interactions are studied by calculating the field structure, assuming that plane electromagnetic waves propagate into a one-dimensional inhomogeneous magnetized plasma. The results obtained by computation are in agreement not only with the laser-target experiments using Nd-glass laser, but also with those using a CO₂ laser. In addition, calculations show the density dip which has been observed in experiments.

STUDY OF THIN FILM WITH COMPLEX REFRACTION INDEX BY SPECTROSCOPIC ELLIPSOMETRY--
OPTICAL CONSTANT DISPERSION AND GROWTH RATE OF ITO

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 3, Mar 86
pp 319-328

[English abstract of article by Feng Hongan [7458 3163 1344], et al., of
Zhongshan University]

[Text] In this paper we propose a method which makes it possible to investigate films with complex refraction index using spectroscopic ellipsometry. By introducing a new aiming function, the search parameter space can be reduced to four-dimensions, enabling us to calculate not only the optical constant and thickness of the films, but also the optical constant of the substrate simultaneously. Using this method we studied the optical constant dispersion and the growth rate of ITO films deposited on Si substrates by sputtering. At the same time we observed that the apparent optical constants of the Si substrates were changed.

STRUCTURAL AND MAGNETIC PROPERTIES OF $\text{Nd}_2(\text{Fe}, \text{Si})_{17}$ ALLOYS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 3, Mar 86
pp 352-358

[English abstract of article by Hu Boping [5170 0130 1627], et al., of the
Institute of Physics, Chinese Academy of Sciences]

[Text] In this paper, structural and magnetic studies are carried out on the alloys of the iron-rich Nd-Fe-B ternary system. The results show that for the iron-rich ($\text{Fe} > 40$ at percent) alloys, a ternary compound $\text{Nd}_2\text{Fe}_2\text{Si}_2$ is formed ($\text{Si} > 20$ percent) as well as a pseudobinary compound $\text{Nd}_2(\text{Fe}, \text{Si})_{17}$, in which Si atoms are substituted for the iron atoms on 9d-sites instead of forming a new ternary compound such as $\text{Nd}_2\text{Fe}_{14}\text{B}$. Upon substitution of Si for Fe, both the cell volume and magnetization of the $\text{Nd}_2(\text{Fe}, \text{Si})_{17}$ alloys decrease, but the Curie temperature T_C increases due to an enhancement of the ferromagnetic interaction in the Fe sublattice. The room temperature anisotropy fields decrease with increasing Si content as a result of the reduction of the plane anisotropy in the Fe sublattice.

CRYSTALLIZATION OF AMORPHOUS Ge IN Ge/Au, Ge/Ag BILAYER FILMS AND Ge-Au, Ge-Ag ALLOY FILMS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 3, Mar 86
pp 365-374

[English abstract of article by Zhang Renji [1728 0086 0165] of the Department of Mechanical Engineering, Qinghua University; Chu Shenglin [5969 5110 7792] of the Department of Physics, Beijing University; and Wu Ziqin [0702 5261 0530] of the Fundamental Physics Center, University of Science and Technology of China]

[Text] In this article, as-evaporated and annealed samples of Ge/Au, Ge/Ag bilayer films and Ge-Au, Ge-Ag alloy films were investigated by TEM. In situ observations of Ge/polycrystalline Au (p-Au) and Ge/p-Ag films during heating were also made by TEM. It was found that the crystallization temperature T_c of amorphous Ge (a-Ge) in a-Ge/p-Au was much lower than T_c of a-Ge/mono-crystalline Au (m-Au). It is shown that the boundary triple points and other interface defects of p-Au films are the favorable nucleating positions for a-Ge crystallization in bilayer films. T_c of a-Ge in the condensation regions of Ge/p-Au films ($\sim 100^\circ\text{C}$) is lower than T_c ($\sim 150^\circ\text{C}$) in the noncondensation regions. There are some large Ge grains in the condensation regions because of the effect of favorable crystallization in local regions. T_c of a-Ge in a-Ge/p-Ag and a-Ge/m-Ag films is about 280°C . T_c of alloy films is higher than that of correlative bilayer films when the metallic content in the alloy film is low ($C_{\text{Au}} < 17$ at percent, $C_{\text{Ag}} < 18$ at percent). T_c of alloy films is lower than that of bilayer films when the metallic content is relatively high. This is because the supersaturation of the metallic ions reduces the crystallization potential barrier of a-Ge significantly.

TEMPERATURE EFFECTS OF OPTICAL PHONON FOR $\text{ZrH}_{1.7}$ AND $\text{PdH}_{0.7}$

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 3, Mar 86
pp 389-392

[English abstract of article by Ruan Jinghui [7086 2529 6540], et al., of
the Institute of Atomic Energy, Beijing]

[Text] The optical phonon spectra for $\text{ZrH}_{1.7}$ (containing 0.2 percent C) and $\text{PdH}_{0.7}$ are measured at room temperature and low temperature (97 K) with a beryllium filter detector spectrometer adjacent to the heavy water pile in the Institute of Atomic Energy. The results show that:

(1) the optical phonon energy level for $\text{ZrH}_{1.7}$ is essentially equal spacing, the width of the energy level essentially does not change with T, i.e., the anharmonicity of the optical phonon is weak and it obeys Einstein's harmonic model.

(2) The second optical phonon energy level spacing for $\text{PdH}_{0.7}$ is about 8 meV larger than that of the first spacing level, and the width of its optical phonon energy level changes from 38 meV at room temperature to 20 meV at 97 K. This means that the optical phonons which play important roles in the superconductivity of PdH_x exhibit significant anharmonicity.

THE $2\Delta_0/(k_B T_c)$ AND PARAMETERS OF PHONON SPECTRUM FOR AMORPHOUS SUPERCONDUCTORS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 3, Mar 86
pp 397-402

[English abstract of article by Cao Xiaowen [2580 2400 2429] of the Institute of Plasma Physics, Chinese Academy of Sciences, Hefei]

[Text] In this paper we propose a formula

$$\frac{2\Delta_0}{k_B T_c} = 4.95 \left[1 - \frac{T_0 \langle \omega \rangle^{\frac{1}{2}}}{A} \left(\frac{1}{\lambda \omega_0} + \frac{1}{20\lambda \langle \omega \rangle} + \frac{1}{20\langle \omega \rangle} \right) \right],$$

to describe the relationships between $2\Delta_0/(k_B T_c)$ and the parameters of the phonon spectrum of disordered and amorphous superconductors for the non-transition metals and their alloys. Here $T_0 = 0.66K$, $A = \frac{1}{5} K^{\frac{1}{2}}$, λ is the electron-phonon coupling constant, $\langle \omega \rangle$ is the average phonon frequency and ω_0 the high frequency cutoff of the effective phonon spectrum $\alpha^2 F(\omega)$. The values of $2\Delta_0/(k_B T_c)$ of disordered and amorphous superconductors which have the known parameters of the phonon spectrum have been calculated. The agreement with the experimental data is within a few percentage points. We show that the amorphous superconductor of non-transition metals and alloys is either a strong coupling superconductor which has a $2\Delta_0/(k_B T_c)$ value much larger than the BCS theory value or a weak coupling superconductor which has a considerably smaller value than the BCS theory one.

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CSO: 4009/76

Physics

TWO-WINDOW FOURIER TRANSFORM TECHNIQUE AND ITS APPLICATION IN SPECTRUM ANALYSIS OF QUANTUM OSCILLATIONS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 4, Apr 86
pp 443-450

[English abstract of article by He Yusheng [0149 6276 3932] of the Department of Physics, Qinghua University]

[Text] The conventional Fourier transform methods were found to give an inadequately accurate and complete spectrum of the quantum oscillation frequencies for some materials with complicated Fermi surfaces, such as IV-VI compounds in the distorted phase. Because of this problem, the early de Haas-van Alphen data of SnTe could not be interpreted properly. The "two window Fourier transform" technique was developed, and it solved this problem successfully in the Fermi surface measurements of $Pb_{1-x}Sn_xTe$ and SnTe. In this technique, spectrum analysis is performed twice for each set of data by using two different windows, referred to as "strong window" and "weak window" respectively, so as to increase the signal to noise ratio and to detect components with weaker strength and resolve neighboring components of similar strength. Therefore, higher detectability and resolvability and better accuracy can be achieved. The results of analysis of the pseudo-SdH simulation signal, consisting of 10 components with different amplitudes, show that the error in frequency of the spectrum is less than 1 percent.

TEMPORAL AND SPECTRAL FEATURES OF $3(\omega_0)/2$ SPATIALLY FINE STRUCTURES IN LASER
IRRADIATED PLANAR TARGETS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 4, Apr 86
pp 459-466

[English abstract of article by Lin Zunqi [2651 1415 3825], et al., of Shanghai
Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] Both temporally and spectrally resolved fine structures of 90° lateral $3(\omega_0)/2$ harmonic emissions were experimentally observed. The existence of $3(\omega_0)/2$ harmonic filaments is attributed to the $3(\omega_0)/2$ harmonic radiation emitted from the neighborhood of the bottom of the moving filament, about $n_c/4$ away from it. The double hump structure with an intense red hump of a laterally emitted $3(\omega_0)/2$ spectrum can also be explained by Doppler correction in addition to the thermal correction due to the fast moving TPD process occurring in the unstable filaments. An estimate of both red and blue shifts using the authors' simple model is quite consistent with experimental results. Experiments showed that the $3(\omega_0)/2$ emission was obviously suppressed using a broad band laser due to more uniform illumination on the target surface and the broad band effect. These may be promising for superhot electron suppression.

LOW-TEMPERATURE MAGNETIC PROPERTIES OF AMORPHOUS $\text{Nd}_x\text{T}_{1-x}$ ($T = \text{Fe, Co, Ni}$)
THIN FILMS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 4, Apr 86
pp 475-481

[English abstract of article by Dai Daosheng [2071 6670 3932], et al., of
the Institute of Solid State Physics, Beijing University]

[Text] The magnetic structure and anomalous behavior of the temperature dependence of magnetization at low temperatures for amorphous $\text{Nd}_x\text{T}_{1-x}$ ($T = \text{Fe, Co, Ni}$) thin films are discussed. It has been observed that the sudden drop of magnetization is at about 20 K, and the temperature corresponding to the sudden drop on the magnetization curves does not change with composition. We suggest that, as the neodymium component exceeds a certain amount, in the ground state the asperomagnetic and speromagnetic structures may coexist for these amorphous alloys. The sudden drop of magnetization at about 20 K may be explained by the phase transition between the speromagnetism and paramagnetism. The critical composition of the neodymium component for coexistence of these magnetic structures approximately corresponds to $x \geq 0.45$, 0.20 and 0.08 for Nd-Fe, Nd-Co and Ni-Ni amorphous thin films, respectively.

THEORY OF FTIR-Q SWITCH RESONATOR

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 4, Apr 86
pp 523-528

[English abstract of article by Zhang Zhenxi [1728 6966 6007], et al., of
the Department of Physics, Northwest University, Xi'an]

[Text] The fundamental theory of the development of the FTIR-Q switch resonator is described. The resonator is composed of many optical elements and cannot be solved by the conventional method. Combining matrix optics with integral equations of diffractions of the optical resonator, we obtain a theoretical solution which produces many quantities, such as Fresnel number, diffraction losses, resonance frequency and its interval, etc., that can be compared with the results of the parallel plane resonator.

EXPERIMENTAL EVIDENCE OF N-S STATE OF NON-EQUILIBRIUM SUPERCONDUCTOR

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 4, Apr 86
pp 540-544

[English abstract of article by Yang Qiansheng [2799 0051 5116], et al., of
the Institute of Physics, Chinese Academy of Sciences]

[Text] Superconducting lead film is driven into the non-equilibrium state by tunnel injection of quasi-particles. There are two kinds of zero resistance states under the same injection level, depending upon the sample history. With the help of double tunnel injection, we found one of them in the homogeneous non-equilibrium superconducting state and the other in the N-S nonhomogeneous one.

RESISTIVE STATE OF NON-EQUILIBRIUM SUPERCONDUCTOR NEAR T_c

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 4, Apr 86
pp 545-548

[English abstract of article by Yang Qiansheng [2799 0051 5116], et al., of
the Institute of Physics, Chinese Academy of Sciences]

[Text] Superconducting Sn films are driven into the non-equilibrium state by tunnel injection of quasi-particles. The voltage across the films starts to appear when injection current increases to a certain value. Near the transition temperature of the Sn films, T_c , the corresponding resistance increases rapidly with the increasing temperature. The behavior is similar to the resistance of the normal-superconductor interface. However, the observed effect is orders of magnitude larger than the N-S interface resistance and the value of resistance will decrease suddenly, even vanish, when the injection current increases to a higher threshold value I_t .

THEORY OF CRITICAL TEMPERATURE FOR SUPERCONDUCTORS WITH SMALL λ (III)

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 4, Apr 86
pp 549-552

[English abstract of article by Weng Zhengyu [5040 1767 1342], et al., of
the Department of Physics, University of Science and Technology of China,
Hefei]

[Text] The T_c formula, derived in previous papers of this series, is
examined by comparing the T_c values calculated from it, either with the
numerical solutions of the Eliashberg equation or with the experimental
values of various superconductors. The agreement between them is
satisfactory for superconductors with small λ .

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IN-FIELD CALIBRATION OF ALBEDO NEUTRON DOSIMETER

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 3, May 86 pp 265-270

[English abstract of article by Lei Zhuanheng [7191 0278 5683], et al., of the Institute of High Energy Physics, Chinese Academy of Sciences]

[Text] The Albedo neutron personnel dosimeter has been more and more widely used due to its small volume and ease in measurement. Attention should be paid to the calibration technique which finally determines the error of the measurement. In fact, there usually exists a certain difference between the energy spectrum of the radioactive source for calibration and that of the radiation field to be measured. In order to improve the accuracy of the measurement, the problem of the in-field calibration technique should be solved. In this paper, the in-field calibration method and the use of the so-called Bonner cylinder for the in-field calibration of the accelerator are described.

SU(9) GRAND UNIFICATION MODEL OF SUBQUARKS

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 3, May 86 pp 271-276

[English abstract of article by Zhang Xinmin [1728 2450 3046], et al., of Xinxiang Teacher's College]

[Text] An improved version of the grand unification composite model proposed earlier is suggested. Under the hypothesis of partly broken global chiral symmetry, we present a four-member family of Fermions at low energies to realize unification of the four-member family of Fermions. The neutrino may naturally acquire the Dirac mass. The proton lifetime and weak neutral current at low energy are consistent with experimental results.

A NEW CO-BOUNDARY OPERATOR AND ITS APPLICATIONS

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 3, May 86 pp 283-287

[English abstract of article by Zhou Guangzhao [0719 0342 0664], et al., of the Institute of Theoretical Physics, Chinese Academy of Sciences]

[Text] In this paper new co-boundary operators are defined in the product form. The associative composition law of the spatial translation group field is discussed using these new operators. The quantization condition of monopoles in $SU(2)$ and $SU(3)$ gauge theories follows easily from the new formalism.

STUDY OF DEEP INELASTIC COLLISION OF $^{12}\text{C} + ^{27}\text{Al}$ AT ENERGY 61.8 MeV

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 3, May 86 pp 323-329

[English abstract of article by Feng Enpu [7458 1869 2528], et al., of the Institute of Modern Physics, Chinese Academy of Sciences]

[Text] By using a ΔE -E telescope and the time of flight detector, the energy spectra of products between ^6Li and ^{16}O were measured for the reaction $^{12}\text{C} + ^{27}\text{Al}$, at 61.8 MeV. The contour plots of the differential cross section in the c.m. system and the angular distributions of emitted fragments were obtained. The calculated values of fully relaxed energies in deep inelastic collisions agree with the experimental values. The mean interaction time of the di-nuclear system was estimated to be from 1×10^{-21} s to 1.4×10^{-22} s.

MICROSCOPIC OPTICAL POTENTIAL CALCULATIONS OF FINITE NUCLEI WITH EXTENDED SKYRME FORCES

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 3, May 86 pp 335-342

[English abstract of article by Yuan Haiji [5913 3189 7535], et al., of Hangzhou University; and Shen Qingbiao [3947 1987 1753] of the Institute of Atomic Energy, Chinese Academy of Sciences]

[Text] Microscopic optical potential calculations in the Hartree-Fock (HF) approximation with extended Skyrme forces are investigated. The HF equation is derived from the variation principle and the potential formula of spherical nuclei is obtained by two different methods. Then the calculations for symmetric nuclei ^{16}O , ^{40}Ca and asymmetric nucleus ^{90}Zr with eight sets of Skyrme force parameters are presented. Our results show that the potential form and varying tendency with incident energy are reasonable and there apparently appears a "wine-bottle-bottom" shape in the intermediate energy region. In addition, our calculations clearly reflect shell effects.

A NEW TRANSITION BRANCH OF THE 5.2 SEC ISOMER IN ^{183}W

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 3, May 86 pp 354-357

[English abstract of article by Gui Shouzao [2981 1108 6644], et al., of the Institute of Nuclear Research, Chinese Academy of Sciences]

[Text] During the bombardment of a 14.8 MeV neutron on natural wolfram samples, a γ -ray with energy of 291.7 keV and halflife of 5.17 ± 0.03 sec is observed. From the experimental facts it is assumed that, in addition to the two well-known transition branches from the decay of the 5.2 sec isomer in ^{183}W , there exists another $11/2^+ 11/2[615] \rightarrow 5/2^- 3/2[512]$ isomeric (E3) transition. The hindrance factor of this new transition is calculated. It is quite consistent with the general empirical rule of the k^- forbidden isomeric transition.

OBSERVATION OF EXCITED STATES IN ^{128}Ba

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 3, May 86 pp 363-366

[English abstract of article by Zhao Zhizheng [6392 0037 2973], et al., of the Institute of Modern Physics, Chinese Academy of Sciences]

[Text] Excited states of ^{128}Ba are investigated via the $^{120}\text{Sn}(^{12}\text{C}, 4n\gamma)^{128}\text{Ba}$ reaction by means of in-beam gamma spectroscopy. A 12^+ state other than the previously reported one is observed according to the properties of the 935.0 keV γ -ray. It does not belong to the ground state band. Two new interband transitions, 224.8 keV and 632.7 keV, are observed and assigned to sidefeeding between the negative-parity band and ground state band.

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4 AUGUST 1986

China Report

SCIENCE AND TECHNOLOGY

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4 AUGUST 1986

CHINA REPORT
SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

ZHANG DENGYI DISCUSSES 'SPARK PLAN'

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 4, May 86 pp 5-7

[Article by correspondent Lu Weiwei [7120 5633 5633]: "A Long-range Plan Stressing Substantial Results"]

[Text] Recently the "spark plan" attracted a great deal of attention from the public. The S&T circle and the comrades related to middle-size and small enterprises and rural enterprises especially showed great interest in the "spark plan." Newspapers and periodicals published articles and talks about the "spark plan."

How can a plan with a target geared to the rural economy to promote "short, medium, and fast" technological items evoke so much of a repercussion in public opinion and in S&T circles? On the eve of the Spring Festival I brought up this question when I visited Zhang Dengyi [1728 4098 5030], director of the Science Policy Research Office of the State S&T Commission.

"Why does the 'spark plan' enjoy immense support?" I came straight to the question in asking Comrade Zhang.

"You asked a good question," Comrade Zhang answered with a well-thought-out plan. "The basic purpose of the state decision about the S&T system reform published last year is to reverse the course of S&T work so that it will serve the economy. In the past year, the 'Decision' has been accepted by more and more S&T workers who have recovered from a state far removed from economic construction. Stressing the economy and meeting the demands of economic development have become new features of S&T work." Thus, the "spark plan" is welcomed by the public. The core of the "spark plan" is applied technology; the purpose is to promote medium-size, small, and rural enterprises and raise the standard of S&T in rural construction to promote the local economy. There is some new wording in the S&T policies and their management. The S&T circle and local workers will all be satisfied." Then Zhang, in an orderly way, explained as follows:

Innovation of Stressing Economy in S&T

For many years the State S&T Commission followed the policy that "economic construction must rely on S&T; S&T work must stress economic construction"

and grasped some medium- and long-term items with strategic significance in the national economy and the people's livelihood. Now the "spark plan" stresses the "short, appropriate and quick" items in S&T having a demonstration and promotional significance to medium-size and small enterprises, especially rural enterprises. It is a strategic ideology with new and profound meanings. What do "short, appropriate, and quick" mean? They mean that the cycle of the commercialization of technological results must be short, they must be applicable to medium-size and small enterprises, and they must be quick in gaining economic results in technological development, which is a policy suited to national conditions. We are a country with 800 million rural people and the development of the rural economy holds the decisive influence in the realization of the grand task of the four modernizations. At present, the structure of the rural economy, along with further rural economic system reform, has changed from single-crop cultivation to multiple-trade-and-professional agriculture, industries, and side occupations. Rural enterprise has grown fast in the past few years and at the end of 1984 the total number of national rural enterprises amounted to 6,060,000. The strength of S&T in these enterprises is very poor; they have few professional S&T personnel and basically the standard is low, energy consumption is high, and the economic results are few. They need S&T urgently. For S&T popularization, rural enterprise is just like a vast ocean. S&T, like a small boat, can roam in this ocean at will. For many years, we have been hoping that S&T would serve to promote the local economy, and there were comrades who did some work in the demonstration and popularization of cultivation and others who advanced some good suggestions in the development of the mountain regions and the shores, yet nothing better has been found. The "spark plan" blazed a new trail. To implement this plan is to deliver to the peasants the urgently needed S&T on which the peasants rely to get rich. For the S&T personnel, they also offer a vast world where their talents can be put to good use. By so doing, both the economy and S&T work will be revitalized and the policy will satisfy both sides.

Zhang said that the "spark plan" has won attention and support from the leaders in the central government. One leader from the central government said: "It is a beneficial undertaking both at present and in the future; it will not work to reform the agricultural structure without promoting rural enterprise without relying on S&T. To combine the two may break a new path to fit the Chinese conditions. Thus it should be taken as a basic policy and adhered to and it will yield unexpected results in the long run."

Correspondingly we too formulated some new regulations about the system of appropriation. In the past, owing to shortcomings in the administrative system, the investment in S&T was gratuitous, with no attention paid to utilization benefit. Some of the funds of the three items in S&T which should have been paid back have not been justly and forcefully recalled. The reform measures of matching investment and paying back are implemented in the "spark plan." The state provides a smaller share of funding and the local government and the enterprise provide a larger share of the funding. The funds, responsibilities, and risks are shared by the three parties of the state, the local government, and the enterprise. Once the technology has acquired economic results, the unit which utilized the funds must repay the state. Development projects conforming to the spirit of the "spark plan"

will receive more support from the state. After gaining some profit, these projects may, according to the situation, repay part of the funds to the state and keep the rest for the local government or the enterprise to continue to develop the "short, appropriate, and quick" projects.

New Attempt at Comprehensive Development

The "spark plan" aims at the "short, appropriate, and quick" items. The technological level needed by these items is not necessarily very high, while the emphasis is on applicability. In the past, some S&T departments strove only for a single target and stressed only the advancement of the technology itself; some comrades engaged in development research often paid attention only to the research itself and neglected to make a complete set in technology in order to transfer the results of the research into research for practical productivity, which resulted in the separation of technology from the economy.

Agricultural production is a complicated system interwoven with the natural environment, living organisms, and human society. Therefore, we must proceed with comprehensive research on a large scale with a wide range. For example, capitalization of the initial costs, the difficulty in processing, and the possibility of ecological pollution should all be considered, which requires coordination among different professionals from different disciplines, to form a complete set among different technologies. This feature has been fully realized in the "spark plan." The majority of its technological items are neither "high, precise, and advanced" nor "small, native, and massive" but rather "small, specialized, new, and high," which is small scale, specialized, and modern and has a high economic results. Since the "spark plan" stresses pragmatism, it can not promote only a single technology but a complete set of practical technology. This raises the level of requirements for the S&T departments and the S&T research personnel, who must study technology and in addition do comprehensive research and development aimed at local natural economic conditions and production demand in order to gain better economic and social results.

Good Situation for Rural Intellectual Development

Zhang said that along with social and economic progress, the people also put forward the demand for agricultural technology for variety and multi-stratification. For example, when people are neither hungry nor cold, they hope to eat better and be clad better and demand that coarse grain be replaced with fine grain and poor quality with fine quality; there is little farmland left in the well-provided areas where people ask for the development of a courtyard economy; in the mountain regions, we should pay attention to water and soil conservation and return the farmland to forest and orchard; and in general, we hope that we can use a small investment to gain great economic results. The purpose of the "spark plan" is to introduce and develop S&T to put an end to the backwardness of rural S&T. Furthermore, all these goals must be realized by the people.

Zhang said that the oft-mentioned term, the challenge of the world's new technology revolution, means in fact competition for the overall promotion of humane quality of life. The significance of the "spark plan" lies not in the handling of several items but in the fact that through the arrangement of some typical and influential items, talent can be cultivated and the quality of the commodity produced by the peasants can be promoted.

One of the important problems in rural development in our country is that the people's knowledge about science cannot meet the demand for development of a commodity economy. According to incomplete statistics, in our country, we have on the average only 1 agricultural student for every 10,000 agricultural workers, professional agricultural S&T personnel make up less than 0.0004 percent of the rural population, while in the United States, of the labor force engaged in agricultural production, 30 percent are college graduates. In West Germany, there is 1 technical advisor for every 350 agricultural households. Compared with the West Germans, we are far behind.

However, we have a great number of school graduates and more than 10 million high school graduates scattered in this vast world, and moreover, each year 2 and 1/2 million senior high school students will graduate and return to the country. They already have basic scientific knowledge but are not trained in specialized technology. Now, facing the new situation in the rural area where the natural economy is being moved toward a commodity economy, they are eager to try but do not know what to do. The poverty of a country is not determined by the lack of natural resources and capital but by its incompetence in developing and utilizing human resources. The "spark plan" puts forward the idea that while promoting appropriate technology, technology development must be combined with the cultivation of local management cadres and technical personnel to make these people the initiators of rural economic development.

In the past, we suggested a policy of "cultivating talent for the rural areas," which has produced some results but lacks practicality and is not widespread. Now, in the implementation of the "spark plan," technical personnel should take the peasants in hand to teach them the technology and turn S&T into a hand weapon for the peasants. If we can reach the requirements of the "spark plan" to train 100 people in 1 county a year, there will be 200,000 people in the whole country in 1 year. Thus if we do this continuously at every level and in every year, a troop with a considerable number of specialized technical people will emerge. And that is why we say that the "spark plan" means not only technological development but, more importantly, means also the development of rural talent and intelligence.

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NATIONAL DEVELOPMENTS

SHANGHAI SCIENTISTS SET UP ADVICE NETWORK

OW290828 Beijing XINHUA in English 0800 GMT 29 Jun 86

[Text] Shanghai, 29 Jun (XINHUA)--More than 600 scientific and technical advice offices have been set up in Shanghai since 1979 to aid modernization and economic growth, a seminar being held here was told. They employ the services of 22,000 scientists and scholars from research institutes, universities, factories and government departments.

The seminar on scientific and technical advice centers in Shanghai began on Friday.

An official from the Shanghai Science and Technology Commission said the service had become an important aid to the city's economy, and over the past few years, the offices had advised on more than 300 research projects of national importance. They have helped with a massive research project, called "China by the Year 2000," to forecast what China will be like by the end of the century. Over the past 3 years, 10,000 scientists have given their views in a set of 72 books. By analyzing how far China is behind developed countries, the authors have proposed policies and other measures to help the country catch up. So far, 60 of the 72 books have been published.

The advice network has helped solve Shanghai's public transport problems. Buses in the crowded city carry 13 million passengers a day, and urban traffic is badly jammed. So advisory offices compiled 50 papers containing proposals for an underground railway, which is now being built.

Shanghai authorities also accepted a proposal to move the city's drinking water source from the lower to the upper reaches of the Huangpu River, which runs through the city. The lower reaches have become polluted by factories. This water project, costing one billion yuan, is expected to be completed next year.

The advisory offices have also offered technical and managerial advice to factories and other businesses, and a survey has indicated that 68 such offices have helped generate 1.9 billion yuan in economic benefits.

Shanghai has also established advisory-service links with foreign countries and United Nations agencies.

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CSO: 4010/64

NATIONAL DEVELOPMENTS

REQUIREMENTS OF TECHNOLOGICAL COMMERCIALIZATION DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANGLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 4, May 86 pp 11-12

[Article by Chen Shijun [7115 1102 0193], Tianjin University: "Discussion on Requirements of Technology Commercialization for Colleges and Universities"]

[Text] Along with further technology commercialization, there have emerged many requirements for colleges and universities. Now let's discuss its several principal aspects.

1. Establish Idea That Scientific Research in Colleges and Universities Should Directly Serve Economic Construction

To meet the demands of technology commercialization, the responsibilities and functions of colleges and universities must be reconsidered. In the past, one school thought that the starting point and goal of scientific research in colleges and universities were to promote academic standards and that the purpose was to promote the development of certain disciplines; another school thought its basic purpose was, through scientific research, to promote the quality of teaching. In my opinion, neither the former nor the latter has fully reflected its due responsibilities and functions. Under the new situation of the S&T system reform, scientific research in colleges and universities must have responsibilities and functions in three areas: promoting scientific development, raising the standard of teaching, and economic construction being oriented, in a straightforward manner. Here the reason I say "straightforward" is that any time people mention education, they often see or think only of its role of promoting economic construction indirectly, that is, through its work, its effect after the cultivated talent is put into the practical production departments. Besides that, scientific research in colleges and universities not only may but also should use their S&T results and their new knowledge and theories to serve economic construction directly. In recent years, many colleges and universities in our country have used their intellectual superiority, talent resource superiority, and better experimental equipment through contracting assignments, technology consultation, technology service, technology training, and cooperative development with the production units and have solved many technical problems directly for the first front of production, which indicates that there are bright prospects for the colleges and universities to serve economic

construction directly. Tianjin University, under the premise of ensuring normal teaching and the completion of the assignments of the state, fully tapped its latent power and helped the enterprises in technical reform, and in 1983 it contracted 173 technical items from production departments. Among them, in the items which passed the evaluation, there were at least three items whose economic result was worth over 1 million RMB.

The responsibilities and functions of colleges and universities in scientific research, by directly facing economic construction, are not only fulfilling the demands of the state S&T policy but also reflecting the world trend in the development of education in colleges and universities. At present, many countries in the world pay special attention to the establishment of so-called "cities of science," "science parks," "industrial science parks," and "industry-teaching associations." No matter what form they use, they necessarily include universities and take scientific research in the universities as their primary force. This shows in one respect the worldwide change in responsibilities and functions of colleges and universities. Prime Minister Thatcher said, presiding over the dedication of the Warwick University science park: "In history, universities have performed two functions: one is to pass the accumulated knowledge on to the next generation and teach them how to think; the second is to create new theories, throw out new ideas, discover scientific laws, invent new hypotheses, and search for the key to open the doors of the unknown world. However, in the past, universities did not have the responsibility to promote and apply new ideas and new discoveries, which were pushed out of the universities. Now the establishment of the science park will give universities a third assignment, that is, to popularize the discoveries and the creative new ideas developed in the universities in society and industry and add them to the wealth of the whole society."

Education in our country must face the world, the future, and modernization; we must fully realize this change in the responsibilities and functions of university scientific research and take the initiative to carry out this change, break the isolation of university scientific research, get out of the small circle in which university scientific research serves only university teaching, face society, and give universities full play to perform their appropriate functions.

II. University Scientific Research Must Stress Both Academic Standards and Economic Results

Scientific research personnel in the universities are different from those in the professional research organizations; the majority of them are teachers primarily engaged in teaching. Owing to the habit of the profession, they often stress theory, systems, and completeness of knowledge and are interested in abstract theoretical research. Besides, they are not familiar with practical production; therefore, they often onesidedly think that only theoretical topics with an impact on some discipline are significant and are not interested in more concrete topics which do not necessarily have an impact on a discipline but can serve economic construction directly with higher economic results. Some even think that research for result promotion and application is substandard. This kind of sense of value is realized not

only in the choice of topic but also in the assessment of the results of scientific research. In the universities the standard of a result of scientific research is evaluated primarily by the academic standards and theoretical significance, with its economic results neglected. It is worth pointing out that not only does this situation exist universally among those who are engaged directly in scientific research, but also it influences the sense of value of management personnel in scientific research. Obviously, this thinking and sense of value, which are disadvantageous to the commercialization of S&T research activities in universities must be really overcome. In the assessment of scientific research results, we must insist on the principle of equal importance in academic standards and economic results; in the assessment of academic titles, we must stress not only the number and quality of theses but also the accomplished results in practical work such as in research result promotion, popularization of the new knowledge, the training of the recipients, and new technology consultation and service; and we must formulate a corresponding reward policy and encourage university teachers to pay attention to the promotion and application of scientific research. To change the onesidedness in this problem, we need to formulate a reasonable and practical system of indexing for assessment of S&T results and S&T personnel to avoid subjectivity and doing things as one pleases.

III. Smash "Pedantry," "Study" Research, Establish Management Standpoint

For scientific research in universities to meet the requirement of technology commercialization, the "pedantic" and "study" style of research must be smashed and the management standpoint must be established including the concepts of customers being first, marketing, competition, economic results, and timeliness.

Since technological results can be treated as commodities, they must be transferred, through exchange, from the owner to the recipient, that is, technical results from universities must be transferred to production departments such as factories or enterprises. To a production enterprise, the technical results bought must meet demand, be quickly digested, and create economic results; otherwise they will not be purchased. Therefore, universities, as sellers of technical results, must consider in technical research how to choose a topic in the beginning, and concerning the nature, scope, material condition, and productivity of the customer, they must think of the customers, stress technical market surveys to master market developments, and pay attention to routine relations with production enterprises. Only by changing the practice and style of "choosing topics blindly, stressing the high, the precise and the advanced, isolated from technical research and not caring who is going to use it" can "marketable" technology commodities be produced continuously.

In general, if we want technical results commercialized, we must develop technology. The majority of topics in technical development are problems that the production departments urgently want solved. Under this condition, it is very likely that several research units will get information about needs from the production department and do the same research at the same time.

since technical development has a shorter cycle and higher possibility of success, research topics are easily repetitive and the competition is keen. For technical results competition, in management, the universities must strengthen their cost accounting in technical research, pay attention to the choice of approach for research and choose possible cheaper available materials, and change the way that has been formulated over several decades in the past that technical research must tackle difficult problems, fill the blanks, and succeed at any cost. The concept of time must be strengthened so that as soon as the result comes out, it should be evaluated, transferred, and sold in time to minimize overstocking and being eliminated through selection and competition.

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NATIONAL DEVELOPMENTS

EXPERTS DISCUSS SCIENCE, TECHNOLOGY DEVELOPMENT

OW230938 Beijing XINHUA in English 0749 GMT 23 Jun 86

[Text] Beijing, 23 Jun (XINHUA)--Today's PEOPLE'S DAILY carried articles by scientists discussing their work and the development of China's science and technology to mark the opening of the third national meeting of the Chinese Association for Science and Technology.

Speaking on the work of the association, Qian Xuesen, vice-president, said that the task of China's science and technology development is a very important part of the country's Seventh Five-Year Plan (1986-90).

He said the association should serve the needs of the country's ongoing economic reforms and strengthen the ties between the natural and social sciences.

The 75-year-old expert in aerodynamics also urged the association to promote scientific exchanges and pay attention to the emerging new sciences and technology.

Zhou Guangzhao, a theoretical physicist and vice-president of the Chinese Academy of Sciences, said more channels should be opened to create favorable conditions for scientists and technology experts to apply their achievements to economic construction.

Personnel training is another point Zhou stressed. He said that personnel training may be carried out in various ways including sending people to study abroad.

However, people trained in China should constitute the main force in the country's science and technology development, he said.

Cai Shidong, a researcher at the Physics Institute of the Chinese Academy of Sciences, said that a favorable academic environment should be created. This means a lot, he said, to those engaged in scientific and technological research.

He also called for more attention to be paid to personnel training and the promotion of science and technology publications.

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CSO: 4010/64

NATIONAL DEVELOPMENTS

S&T COMMISSIONS, ASSOCIATIONS TO INVIGORATE LOCAL ECONOMY

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 4, May 86 pp 1

[Extract of Fang Yi's [2455 3015] address at the National S&T Conference, edited by You Siyi [3266 1835 1837]: "S&T Commissions, Associations Should Invigorate Local Economy"]

[Text] 1. Situation in the rural area. This has been explained very clearly in the suggestion about the "Seventh 5-year Plan" from the central government and Document No. 1 of this year. Here I mention only three figures: one is that our country has fed 22 percent of the world's population with 7 percent of the world's arable land; the second is that in the past 5 years, our national agricultural output value has been increasing rapidly with an average annual rate of increase of 10 percent; and the third is that our 1 billion population owns 800 jin of grain per capita, which is close to the world standard. Just with these three figures it is enough to say that the development of the rural areas in our country is the best since the founding of the country, and this achievement has become the focus of world attention. This agricultural success, in the final analysis, should be credited to "policy and science." The economic reform and policy adjustment in the rural areas are very successful and they should be further emphasized and perfected. Besides, there is great potential for the promotion of the rural economy with S&T. At present, the yearning for S&T in the rural areas is increasing day after day, and with the reform going deeper and with the development of commodity production, the yearning will become even sharper. One of the important points in Document No. 1 of this year is to use S&T to promote the rural economy. We must have a sufficient understanding about development in the rural areas, proceed from the natural conditions and the local economic situation to grasp firmly the work of agricultural technology popularization, and fully support the rural enterprises' determination to execute Document No. 1.

2. The vast rural area is a huge world which gives full play to the immeasurable forces of S&T and to the intelligence and wisdom of S&T personnel. More and more people understand the rule that there is "no stability without agriculture, no richness without industry, no circulation without commerce, and no prosperity without ability." By "ability" I mean mainly S&T and the people who have mastered S&T; these are the keys in the promotion of

agriculture, industry, and commerce in the rural areas. Only if the comrades in the S&T commissions and associations do a successful job of promoting the local economy can the vitality of S&T be maintained. Therefore, in serving the local economy, the work of the S&T commission must be strengthened and also the work of the S&T office; we must be united and fight to carry out the grand plan of providing appropriate contributions to the realization of the goal of being comparatively well off before the end of this century.

3. The S&T commission is an adviser to the S&T work of the various levels of party commissions and governments, and its principal obligation is to take care of the overall planning, to organize to tackle key problems, to formulate policies, and to coordinate the management of S&T work. The S&T commission is a mass organization of S&T and an aid to the party and government in the development of S&T. Its principal obligation is to unite and organize the S&T workers and arouse the socialist enthusiasm of these people and to serve the economy and the construction of the two civilizations through the exchange and popularization of S&T.

It is a long-term strategic task to popularize S&T and raise the national standard in the knowledge of science, and all the S&T commissions, S&T associations, and the related departments and groups should bear this responsibility and give their superiority full play. This requires both coordination and a clear division of labor. The S&T commission has formulated the "spark" plan with a specific orientation and specific requirements and it must be well organized and carried out. The principal obligation of the S&T associations is to popularize S&T and assist in the training of S&T personnel.

Personnel cultivation is a key link in the work of local economic promotion. At present, it is still a weak link and we should take measures to make it yield results.

Local S&T commissions and associations at various levels should respect, support, help, and coordinate with each other and unite and struggle to promote the local economy.

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NATIONAL DEVELOPMENTS

HAJIF-III PROGRAM FOR NONLINEAR ANALYSIS OF AIRCRAFT STRUCTURES

Beijing GUOJI HANGKONG [INTERNATIONAL AVIATION] in Chinese Apr 86 pp 9-11

[Article by Li Ximing [2621 0823 2494] and Zhang Xuefeng [1728 1331 1496]:
"Nonlinear Analysis System for Aeronautical Structures--Brief Introduction
to HAJIF-III"]

[Text] A HAJIF-III program including 80,000 FORTRAN statements for non-linear structural analysis has been developed by the Chinese Aeronautical Establishment (CAE). Five fundamental functional subsystems, the monitor, the finite element analyzer, the data file manager, the preprocessor, and the postprocessor are included. Besides 89 fixed analysis flows designed for linear analysis, thermal stress analysis, and a variety of nonlinear analysis, its 44 function modules provide the possibility for users to form new flows fitting their own problems in hand. In the development of the system, a multiple substructure technique is used. A new device for automatically determining the DoF of the analyzer structure and a new computationally effective self-adaptive mixed solution technique for nonlinear analysis are presented. The user-friendly preprocessor and postprocessor and the abundant element library, material library, load library, and algorithm library make it easy to use not only for large aeronautical structures, shipbuilding, and civil application, but also for research. Seven practical structure applications show that the HAJIF-III is very cost-effective for engineering analysis.

The HAJIF-III is a system for the nonlinear analysis of aeronautical structures that was developed by the leaders of the CAE. The work on developing it began in 1981. In October 1984, the scheduled goals for its development were reached, and, after a year of application, in November 1985, it was authenticated by organizations of the Ministry of Aeronautics Industry.

In the guiding idea behind the development of HAJIF-III, besides that it should meet the demands for the usual design of large program systems, particular stress was put on the following three aspects:

1. When seeking a solution to a problem of linear analysis, under the circumstances of insuring fairly good precision, to strive for fairly good economy.

2. The system must easily link up with the CAD system, so as to become the main analysis software of the CAD system.

3. Strive for a program design in accordance with the methods of software engineering. The HAJIF-III is composed of five parts: control program, dynamic function module, data file management system, preprocessing system, and postprocessing system. The entire system has 89 user-selected fixed flows, 44 function modules, 1,117 subprograms, and nearly 80,000 FORTRAN statements. A brief introduction to the system follows:

Problem Solving Scope

The HAJIF-III can make the following structural analyses:

1. Static linear analysis;
2. Thermal stress analysis;
3. Plasto-elasticity analysis;
4. Curve analysis (comprising nonlinear curve, linear curve, and Euler's curve analysis);
5. Large displacement on large deformation analysis; and
6. Plasto-elasticity analysis under circumstances of large displacement.

The objects of the HAJIF-III's computations can be divided into two types:

1. The structure of aeronautical and astronautical vehicles, including rigid frame, truss, various types of thin-walled, axially symmetric bodies, and various types of adapter structures;
2. Other structures, including boat and ship, various types of high-rise buildings, dams, bridges, tunnels, chemical industry containers and pipelines, and other machinery structures.

The HAJIF-III has techniques for analyzing complete structures and many kinds of substructures. Therefore, it is suitable both for analysis of large structures and for small-scale computation in topic research.

Element Library

The HAJIF-III now contains more than 20 elements. Among them the greater part are conventional elements of bar, beam, plate, and shell. There are also one-dimensional, two-dimensional, and three-dimensional switchback points and other reference elements. The two types of elements exist side by side, and can be mixed together and used. The elements used for nonlinear analysis are set up as formulas according to T.L. (Total Language Formulated) and U.L. (Updated Language Formulated). The two-dimensional reference elements can

process plane stress membrane elements, plane strain elements, and axially symmetrical elements. The three-dimensional elements of the switchback points can stimulate space arbitrary shape masses. Because it can, through methods of release in degree of freedom, release the dropped beam end's moment of force, it will not be drawn into the transitional beam element. The element library has a standard interface, so it is very convenient for the user to add other necessary elements.

Material Library

The HAJIF-III's material library is abundant, and can handle nonlinear problems on various kinds of material. There are four methods of describing the stress-strain curve of material:

1. The Ramberg-Osgood three-parameter equation;
2. The power-series expression that describes segments;
3. The exponential expression; and
4. The test curve description (providing certain test points from the system's quasi-expressions).

The HAJIF-III now contains the following material models:

1. Isotropic linear elastic model;
2. Orthogonal opposite-line elastic model;
3. Isotropic thermoelastic model;
4. Telemechanical hardened model;
5. Directional hardened model;
6. Elasticity-ideal plasticity model; and
7. Isosclerotic model.

All models in the system are independently operated, and there are standard interfaces for them, a feature which provides convenient conditions for revising or for adding or subtracting material models.

Load Library

The loads that the user can provide are: 1) concentrated load; 2) distributed load; and 3) quasistatic thermal load.

The system also has an aircraft wing area load computing program for the user's use. In addition, the program has an interface so that the user's load computing program can be linked to it.

Algorithm Library

As everyone knows, in nonlinear analysis there are no methods of solution that are effective for various types of nonlinear problems. Based on this situation, the HAJIF-III's algorithm library has been provided with various methods for the solution of nonlinear sets of equations, which the user can select and use. These methods are: straight incremental method, Newton's method, revised Newton's method, accelerated convergent revised Newton's method, quasi-Newton's CBFGS and DFP methods. There are also the linear search technique, the incremental added-load arc length method, and the current stiffness parameter method. All these methods combine to form various methods of solution.

When computing an incremental add-on load, in order to be able to select automatically a method of solution in accordance with the specific property of the structure for which a solution is sought (meaning that the degree of nonlinearity of the structure is calculated by current stiffness parameters), so that the seeking of the solution is most economical, a self-adapting mixed method has been specially designed. Results of using it have been fairly good. In addition, the system possesses the capability of providing the user with an automatically selected optimum load increment. This is very convenient for users who lack experience in nonlinear analysis.

When seeking a solution to a curve problem, the system contains the generalized inverse power method that seeks the minimum characteristic of the original point shift by accelerated convergence.

The system contains multiweighted substructure techniques and static polycondensing techniques. The maximum number of substructure series is 10, and each series is divided into 99 substructures. The substructure technique and the static polycondensing technique are effective methods for lowering the degree of freedom of the substructures.

Convergence Processing

For convergence processing the HAJIF-III has the following four methods:

1. Single-point convergence (including zero position shift and given position shift convergence);
2. Master-slave convergence;
4. Generalized position shift multipoint convergence; and
4. Nodal point coordinate convergence.

By using the above four processing methods, the system can process all kinds of boundary conditions that are encountered now.

Results Provided by Analysis

Based on the required analytic content, the following results can be provided by this system's analysis:

1. It can provide all the results that a linear analysis program can provide;
2. Thermal stress on the structure;
3. A history of the changes in stress, strain, and position shift caused by a load, and the plasticity boundaries of the structure;
4. Critical stress, critical load, and curve model. If part of the structure is a curve at first and then the overall structure is destroyed, the system can provide the load at the time of overall destruction;
5. If a structure's strength needs to be calibrated and checked, the system can provide the residual strength coefficient.

Preprocessing Function

The HAJIF-III's preprocessing subsystem contains more than 20 kinds of functional statements, including repetitive statements, mathematical function statements, and geometrical statements. It can automate the finite element net differentiation and generate or revise data, thereby reducing the user's work in preparing data. It also possesses the function of making the structure drawing. What should be particularly pointed out is that the preprocessing subsystem of this system can read out and change raw data provided by other programs recorded on tape by the user for the HAJIF-III's use. This provides very convenient means for a user to use this system.

The preprocessing subsystem of this system is an independent module. It can be linked to any other finite element analysis system for use by the other system.

Postprocessing Function

The HAJIF-III's postprocessing system possesses the functions of tabulating and charting: If data output is needed, it can output them in clearly tabulated form, and can directly bind them into book form, thereby reducing the user's work in extracting data and arranging charts. It can draw a diagram of a structure's external shape so as to be seen from any desired angle, draw a finite element net partition diagram, and draw a structure deformation diagram. It can draw the results of computation into various curves. It can draw curved model axes diagrams and contour line diagrams.

System Design

The basic idea behind the design of the HAJIF-III program was to make use of software engineering methods; to assimilate the strong points of all types of foreign structure analysis systems; to formulate quality standards and design scope; to get a good grasp of the main links in structure design and algorithm design; to do well the program design and the testing work; and to develop a structure analysis system that is flexible, convenient, dependable, and highly efficient.

The purpose of formulating quality standards was to insure that it is convenient to use, its functions are complete, its structure is dependable, its cost is low, and its safeguarding is easy.

The design scope included quality guarantee standards, engineering terminology standards, software design requirements, program code arrangements, and program testing principles.

The algorithm design was conscientiously made to carry out algorithm analysis, make correct proofs, and choose the optimum algorithm in order to insure that the system is highly efficient and the computing economical. The self-adaptive unit empty load method set forth by this system to determine the nodal points of the finite element net has been shown through use to be simple and reliable.

The system's structure is an hierarchical tree structure with the hierarchies distinct and the functions single and clear.

The interfaces of the element library, material library, algorithm library, and the various processing function modules have been standardized, formalized, and weakened, so as to make it easy to enter new elements, new material types, and new methods.

The system design is a structuralized program design that proceeded from top to bottom and that is gradually refined. The program is easy to read, easy to revise, and easy to safeguard.

All of the interface parts of the computer hardware and the system software are concentrated in a small number of models, and are written in standard FORTRAN statements, making it easy to transplant them to other kinds of machines.

Application of the System

During the process of developing the system, a comprehensive examination was made of all the elements and function modules and all the analytic flows, in which more than 400 large, medium-sized, and small examination questions were computed. Since the end of 1984, the system has made computations on seven items of four aircraft. This not only solved some problems in aircraft design and engineering practice that urgently needed to be solved, but also further

tested and verified the system's reliability. Thus good economic results have already been obtained. These practical applications showed that structural analysis by this system can provide a basis for rationally distributing the structure, lowering the structure's weight, and reducing the number of some experimental projects. Therefore, this system provides a powerful instrument for model design and topic research, and it will lead to clearer and clearer social and economic results.

The HAJIF-III is now in operation in two 7760 computers. The system's functions will be expanded so that it will be able to seek solutions to problems of dynamic nonlinear responses, fatigue, and fracture mechanics.

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NATIONAL DEVELOPMENTS

STATUS OF CHINESE HELICOPTER INDUSTRY OUTLINED

Beijing GUOJI HANGKONG [INTERNATIONAL AVIATION] in Chinese Apr 86 pp 12-14

[Article by Wang Shicun [3769 6684 1317]: "Our Country's Helicopter Enterprise"]

[Text] The development of our country's helicopter enterprise began in the mid-fifties. At that time, based on the state development plan, on the one hand we copied the Soviet Mi-4 helicopter and provided it for domestic use; on the other hand, we began to offer helicopter speciality courses in schools to train technical talents in this field.

After more than 30 years of construction, our country's helicopter enterprise now possesses a definite scale: two manufacturing plants and one research and design institute. In addition, in the Low-Speed Aerodynamics Research and Development Center there is a helicopter aerodynamics research team; in the Test Flight Research Center there is a helicopter test flight team; and in the Nanjing Aeronautical Engineering College there is a helicopter teaching and research section. It may be said that our country's helicopter enterprise, in the scientific, designing, manufacturing, and educational aspects, has been formed into a fairly complete system. However, in technology, for various reasons, a lot of time has been wasted and, in comparison with the world's advanced level, there is a definite gap. Below is a brief introduction to the main units in our country that engage in helicopter research, as well as the general situation of their development.

Harbin Aircraft Manufacturing Company

It is one of the key enterprises in our country's aeronautics industry. Established in 1951 and 1952, it has produced about a dozen kinds of aircraft and helicopters of four big types. The company now has 17,000 staff and workers and 2,500 engineers and technicians. It has fairly advanced production equipment, and it possesses a fairly strong capability for development. The company, getting patents from Aerospatiale of France, is now manufacturing the "Dolphin" light helicopter.

The Harbin Aircraft Manufacturing Company is our country's main plant for manufacturing helicopters. In February 1958, in accordance with the blueprints and technical data for the Mi-4 helicopter, which were provided by the Soviet side at that time, it began to make a copy of this helicopter. The first test flight of which took place in December of that year. The code name of this helicopter at that time was "Xuanfeng [Whirlwind]-25." In 1959, after state authentication, it was put into batch production. From this time on, our country's helicopter production technology began gradually to develop.

The "Xuanfeng-25" is a single-rotor helicopter. The diameter of its rotor is 21 meters. The helicopter's takeoff weight is 7,200 kilograms. It has one piston engine (a copy of the Soviet Ash-82), and the engine's rated power is 1,250 kilowatts. In its early stage, the Mi-4 helicopter's blade was a composite structure of metallic tubular beams and wood. In the sixties, the company developed on its own a metallic blade of aluminum alloy with girders carrying a honeycombed back-forged piece. Thus in rotor technology level it caused a generational replacement. Following complete manufacture in China of the copy of the Mi-4 helicopter and the improvement of its blade, the helicopter was named in China the "Zhi-5." The Zhi-5 helicopter has developed into models for passenger transport, rescue, aerial survey, and lifesaving at sea. Up to 1979, when production was stopped, more than 500 had been produced, and they played a very big role in the national economy and in national defense construction.

During the course of producing the Zhi-5, the Harbin Aircraft Manufacturing Company test-built several other helicopter models. Among them a fairly successful one, which was developed in cooperation with another unit, was the Zhi-6 helicopter. The Zhi-6 was developed on the basis of the Zhi-5. It has a redesigned airframe and is fitted with a turboshaft engine. The engine's axial rate is 618 kilowatts, and the aircraft's takeoff weight is 7,600 kilograms. In 1968, the Zhi-6 made its first test flight, and was then put into test-production.

To raise the technological level of our country's helicopters, in October 1980, with the approval of the Chinese and French governments, the China National Aero-Technology Import and Export Corporation signed a contract with Aerospatiale of France and the Turbomeca Corporation for the transfer of the manufacturing rights for the SA 365 N/N1 "Dauphin" [Dolphin] helicopter and its engine, under which the Chinese side would assemble and produce 50 helicopters and 100 engines. The Harbin Aircraft Manufacturing Company became the main helicopter plant, and was responsible for the tasks of producing, assembling and test flight of the helicopter. In China this helicopter was designated the Zhi-9, and at present more than 20 of them have been assembled and produced. All of them have been cosigned to the Civil Aviation Administration of China [CAAC], military units, or the China Maritime Helicopter Company. Through the import of technology, the Harbin Aircraft Manufacturing Company and other relevant factories are now carrying out a series of technological transformations in order as fast as possible to make our country's helicopter manufacturing technology attain the level abroad at the end of the seventies and the beginning of the eighties.

The China Helicopter Research and Design Institute

This institute, located in Jingde City, Jiangxi Province, was set up in 1968. Its basic task is, in accordance with the state development plan, to undertake the work of helicopter research, design, test, and test flight. The institute now has a little over 1,200 staff and workers, of which nearly 600 are scientists and technicians.

Through about a dozen years of development, the China Helicopter Research and Design Institute has now formed a design group with a certain capability for actual work. In the institute are 16 research offices, whose specialities include overall, aerodynamic, strength, structure, lift, system, and ad hoc research. The institute also has the necessary technical support units. The academic disciplines are complete, and its specialities form a complete set. The institute also has a computing center. The institute possesses a variety of experimental methods and testing equipment. It can carry out static tests on the whole aircraft, dynamic tests of its parts, and fatigue tests; tests of the fuel, operating, electrical, and ad hoc systems; as well as continued tests of the helicopter as a whole.

The institute also possesses a certain capability for test-manufacture and processing. Its test-manufacture factory has more than 400 production workers and auxiliary workers. It has more than 150 metal-cutting machine tools of various kinds that are able to machine equipment for ordinary tests and parts for helicopter tests.

Since the institute was established, it has done work on designing, test-manufacturing, and testing several kinds of helicopters (including the Zhi-6). It is now engaged in research on improving and modifying helicopters. In addition, making use of its own technological superiority in other fields, like the development of a wind-driven generator, it is serving national economic construction.

Changhe Aircraft Manufacturing Plant

This plant was set up at the same time as the China Helicopter Research and Design Institute, and is also located in Ningde City, Jiangxi Province. It is the main aircraft plant in South China. It has a little over 6,000 staff and workers, of which a little over 700 are technicians. The plant occupies an area of about 2.3 million square meters, and the area of its factory buildings is 130,000 square meters.

After 10-odd years of construction, the plant preliminarily possesses the capability for producing medium-sized helicopters. It has more than 1,000 pieces of universal- and special-purpose equipment, including large cutting machine tools and precision machinery tools. The plant has also set up a central measurement office and a central testing office, which have the equipment to make the various measurements and tests needed in helicopter production.

The Changhe Aircraft Manufacturing Plant has produced the main parts for several kinds of helicopters, such as the rotor blade, the automatic tilter, and the tail propeller; and it has assembled various kinds of helicopters. This institute and the China Helicopter Research and Design Institute, in coordination with several dozen relevant units throughout the country, developed the multi-purpose helicopter--the Zhi-8--which was flown for the first time on 11 December 1985 at Jingdezhen. The Zhi-8 is a large helicopter of a single rotor type with tail blades. Its takeoff weight is 13 tons.

Baoding Propeller Manufacturing Plant

This plant is located in Baoding City, Hebei Province. It began to be set up in 1962, and in 1964 it was established and put into production. It has mainly undertaken the design, development, and production of the airscrews on various types of aircraft and the propeller hubs and tail propellers on helicopters. In addition, it produces vanes for various kinds of wind-driven machines.

The Baoding Propeller Plant has 2,600 staff and workers, of which 220 are engineers and technicians. The factory building area is 34,000 square meters. In the plant are propeller production workshops, total assembly workshops, as well as fatigue testing offices and composite material testing offices. It also has design and technical offices.

The plant has more than 350 pieces of equipment of various kinds, and its annual output of various types of propellers is about 1,000. It is now producing flexible propeller hubs and duct tail propellers for the "Dolphin" helicopter imported from Aerospatiale of France.

Low-Speed Aerodynamics Research Institute

A research institute under the China Aerodynamics Research and Development Center, it is located in Mianyang Prefecture, Sichuan Province. The institute has a Helicopter Research Office, which specially engages in research on helicopter aerodynamics.

Since it began research work on helicopter aerodynamics in 1967, the focus has been on wind tunnel testing of helicopters. The institute now has two wind tunnels for testing helicopters. One is a conventional flow-type wind tunnel. Its testing section is 4 by 3 meters, and its maximum wind speed is 100 meters per second. It can carry out tests on rotors with a diameter of 2 meters. The other one is a series direct flow-type wind tunnel. Its first testing section is 12 by 16 meters, and has a maximum wind speed of 25 meters per second; the second testing section is 8 by 6 meters with a maximum wind speed of 100 meters per second, and can carry out slow tests on rotors with a diameter of 4 meters.

Through many years of trials and hard work, the institute has developed a set of devices used in 4 by 3 meter wind tunnel tests of helicopter models. They mainly include a 35-kilowatt variable-frequency electric machine rotor drive system and two floating frame balances. Of the latter a rotor balance and a fuselage balance can respectively measure the six aerodynamic weights on the rotor and the fuselage. By making use of these devices, both isolated rotor tests and rotor-fuselage combination tests can be conducted. The institute once used a standard rotor model it had made for a proof and check test. In addition, to coordinate with helicopter model research, it also conducted strength measurement tests that included several kinds of helicopter rotors within the Zhi-6 series.

The helicopter model testing device inside the 8 by 6 wind tunnel is now being used for debugging. It uses an 830-kilowatt direct current electric machine to provide the motive power for the rotor, and a ring strain balance is used as the strength-measuring component.

In addition, the institute has initiated the following research projects: research on methods for measuring the wave angle of rotor models; research on techniques for measuring the moment of force on rotor model hinges; research on testing rotor model flutter; and research on rotor/tunnel wall interference. To compare tests, the institute also computes rotor aerodynamic load and rotor flutter.

Flight Testing and Research Center

Located in Xi'an Prefecture, Shaanxi Province, the Flight Testing and Research Center began to be set up in 1959. Its principal task is to be responsible for state design-finalization test flights of new types of aircraft as well as test flights of a research nature.

The center has about 1,000 technicians. It is divided into a research department, a measurement and data processing department, an instrument design and manufacturing department, and a flight department. It also has a factory that makes nonstandard testing devices. Under the research department are 10 research offices, among which there is an aircraft test flight research office that includes a helicopter test flight team.

The Flight Testing and Research Center has more than 40 aircraft of various types. It has a large amount of ground testing facilities, such as a flight simulator, an engine test-run platform, and an ejector seat test platform. In addition, it has a 3,400-meter-long runway.

With regard to helicopter test flights, the test flight team has conducted comprehensive test flights of the Zhi-5 and Zhi-6, that is, it has measured their basic performance, their stability, operability, and maneuverability, as well as their stress. In addition, the test flight team has done a lot of test flight research on helicopters, such as research on the specific aerodynamic properties of helicopters, research on their flying quality, as well as measurement of their vibration.

For many years, while doing test flight research work, the test flight team has initiated applied research on Kalman filtering techniques, and has come up with its own set of data processing methods. Also, it has obtained certain results in research on parameter-distinguishing techniques when a helicopter is in highly turbulent motion, and in the formulation of standards for helicopter flying quality.

Nanjing Aeronautical Engineering College

It is an institution of higher learning that trains high-level technical talents in aeronautical engineering. Founded in 1952, it is now one of our country's key institutions of higher learning. The college has 10 departments. In the aircraft department there is a helicopter engineering teaching and research section.

The helicopter engineering teaching and research section was set up in 1957. Originally part of Northwest Industrial University, it was moved to Nanjing Aeronautical Engineering College in 1970. After 28 years of building, the teaching and research section now has more than 30 teachers. They engage in teaching and scientific research work in aerodynamics, flight dynamics, and helicopter strength and design.

The main equipment of the helicopter training and research section is a rotor laboratory and a large low-speed wind tunnel that can test helicopters and VTOL [vertical takeoff and landing] aircraft. The wind tunnel is of the series cyclonic flow type. The size of its first testing section is 5.10 by 5.25 meters, and it has a maximum wind speed of 32 meters per second; the second testing section is 3.0 by 2.5 meters, and it has a maximum wind speed of 90 meters per second.

From 1961 to the present, the Nanjing Aeronautical Engineering College has trained more than 600 graduates in helicopter specialties. The great majority of them have been assigned to work in relevant research institutes and factories, as well as in the CAAC and military units. Now, every year 35 to 45 B.A.'s, 4 to 6 M.A.'s, and 1 to 2 Ph.D.'s are trained in the helicopter specialties.

In research on helicopter technology, the Nanjing Aeronautical Engineering College has made the following achievements.

1. Research on rotor aerodynamic load. Based on classical rotor vortex flow theory on tailflow models, it has come up with a method for computing a rotor blade's aerodynamic load and its stress analysis. The computer program for this method has been widely popularized and applied in our country.
2. Design of the Y-2 light helicopter. This was the first helicopter designed by our country on its own. Plans for it began in 1965, and in 1975 the aircraft's first test flight was successful. The Y-2 is a single-rotor light helicopter with three rotor blades. Its rotor diameter is 10 meters. It is fitted with a 260-horsepower piston engine, and its normal takeoff gross weight is 1,555 tons.

3. Development of a composite material rotor blade. To improve the performance of the Y-2 helicopter, the Nanjing Aeronautical Engineering College developed for it our country's first composite material rotor blade, completing the development in 1982.

In addition, some departments that use helicopters, like our country's Air Force and Navy as well as the CAAC, also have some research institutes and repair plants that possess a certain level of helicopter technology.

To promote the flourishing of our country's helicopter enterprise, in October 1984, with the approval of the China Aeronautics Society, the Chinese Helicopter Professional Committee was established. Members of the professional committee not only include technicians of the above-mentioned units, but also technicians of helicopter engine plants as well as technicians of the Air Force, Navy, and CAAC. Its establishment provides good conditions for widespread academic interchange and technical explorations by experts, engineers and technicians of our country's helicopter industry, and the committee plays an important role in developing our country's helicopter enterprise.

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NATIONAL DEVELOPMENTS

CHINESE-DEVELOPED GAS TURBINES LISTED

Beijing GUOJI HANGKONG [INTERNATIONAL AVIATION] in Chinese Apr 86 pp 15-16

[Article by Li Huaidd [2621 2037 1221] and others: "Advances in Development of Chinese-Made Light Gas Turbines"]

[Text] In 1984, the State Machine-Building Industry Commission, the State Science and Technology Commission, and the National Defense Industry Office jointly set up the Gas Turbine Applied Research Work Group, and called on relevant units, besides aeronautics, to use it in development work on gas turbines in the ship and industry domains. The party organizations of the Ministry of Aeronautics Industry actively responded to this call, and made a resolution "to vigorously develop gas turbines, put them in the service of energy resources and communications, and implement the policy of maintaining the military industry while switching to the civilian industry, combining the military and the civilian."

Since that time, research work on the use of gas turbines in industry, on ships, and locomotives has developed from the dispersed "stage of spontaneous development" to the overall planning and arrangement "stage of conscious development." During the Sixth Five-Year Plan period, striking progress was made in this research work.

The light gas turbine is a power device derived from the aircraft engine. Its strong points are that it is small in bulk, it starts up fast, and it does not use cooling water. By using it complete sets of units for various purposes can be formed—generating units, locomotives, and ship power devices—and water pump and compressor units. This light gas turbine carries on the advanced technology of and experience in using aircraft engines. Therefore, its total project investment is less. Besides being able to use light oils (fuel oil and diesel oil) and natural gas as fuel, this light gas turbine can use crude oil, heavy oils, and low calorific value fuels. Thus it provides new approaches for opening up new sources of energy and achieving a cascading utilization of energy services. Since 1976, the Ministry of Aeronautics Industry has developed in succession 13 modified light gas turbine models from 5 kinds of aircraft engines (see Table 1). From the beginning to the end of the Sixth Five-Year Plan period, the Ministry of Aeronautics Industry successfully developed and put into production and use 9 models from 4 kinds (see Table 2); they are now being formed into complete

sets and allocated to every large oil field for use in generating electricity, supplying heat, and pumping gas; to coal mines for extinguishing fires; and to hovercraft and experimental railway locomotives (see Table 3). A unit of them is roughly calculated to have an operating time exceeding 190,000 hours, and a single one's longest operating time reaches 13,400 hours.

The Wojiang [turboprop]-6 (WJ6) aircraft engine produced by the Nanfang Power Machinery Company in Zhuzhou City, Hunan Province, and used on the An-12 and Yun-8 aircraft, has been made into modified models which respectively provide the motive power for portable power stations in oilfields and gas turbine sets for compressors, hovercraft, and experimental railway locomotives. Since it began to be developed and put into production in 1973, 42 of the uniaxial Wojiang 6 Gai [modified] I (WJ6G1) have been produced. Formed into complete sets from the YD-2000 container-type portable power station, it has been successfully used in the Changqing, Renqiu, and Zhongyuan oilfields. A single one is roughly calculated to have an operating time exceeding 10,000 hours. The diaxial Wojiang 6 Gai II (WJ6G2) has been technically authenticated, and the WJ6G2C has been fitted onto the top of the Long March I locomotive and has had a trial operation. In 1985, gratifying progress was made on the Wojiang 6GIV (WJ6G4) locomotive power unit, which is being developed.

There have been more than 20 years of experience in using the Wopen [turbojet] 6 (WP6) aircraft jet engine, which is produced by the Liming Machinery Company in Shenyang City. Work on developing a modified set of these engines began in 1979. In 1983 the Wopen 6 Gai (WP6G) set was put into operation as the adjusted peak electricity generating device for the company's factories. In the same year, this company signed a contract with the Beiya Power Station in Daqing Oilfield for a heating and power parallel supply unit fueled by natural gas. In October 1984, the unit was formally put into operation, becoming our country's first heating and power parallel supply unit. By 13 January 1986, this unit was roughly calculated to have been in operation for 8,917 hours, generating 34,76 million kilowatt-hours of electricity and producing 90,351 tons of steam. To insure the regular operation of the unit and for the convenience of the consumers, the business practice of "buying gas, selling electricity, and selling steam" was initiated.

The Wojiang 5 (WJ5) aircraft engine used on the An-24, Yun 7, and Yun 7-100 aircraft is produced by the Harbin Aircraft Engine Manufacturing Plant. In 1979, two generating units equipped with the WJ5G gas turbine, a modified model of the WJ5 engine, were consigned to the Xinjiang Oilfield for its use. In 1984, the YD-1250 portable power station equipped with the modified model was put into use in the Daqing Oilfield. The Wozhou Gai [turboshaft modified] (WZ5G) gas turbine composed of the WJ5 engine and a power turbo-shaft, was successfully trial-manufactured in 1978 by the No 2 Machinery Research Institute of Wuxi City, and was used on the water-pumping unit of the Karamay Oilfield in Xinjiang. In 1985, success was obtained in a test using the DQ-1000 inert gas fire-extinguishing device, which has the WZ5 engine as its main engine, for both working and simulating fire extinguishing at the Pingxiang Coal Mine in Jiangxi.

In December 1984, the Sozhou 6 Gai (WZ6G) water-pumping unit, developed by the Lehe Machinery Plant in Jiangxi, was debugged at the Zhongyuan Oilfield. The WZ6G water-pumping unit uses the RST-6 electronic fuel regulating system, which was developed by the Xi'an Aircraft Engine Accessories Manufacturing Plant. As of now, this unit has been in trial-operation for 2,400 hours, and the amount of water it has pumped exceeds 170,000 cubic meters.

The Woshan [turbofan] 9 (WS9), which is produced by the Xi'an Aircraft Engine Company, is an aircraft engine whose performance in China is currently fairly good. There are three kinds of gas turbines developed and refitted from it (see Table 4). Platform stand performance debugging has been completed on the Woshan 9 Gai I A (WS9G1A) industrial-use gas generator, and it is now being manufactured as a complete set with a power turbine. The Woshan 9 Gai II (WS9G2) gas generator is now undergoing tests.

Development work on our country's gas turbines started a little later than that of foreign countries, and its starting point was also fairly low. For example, unit efficiency is not high, the continuous operating time of gas turbines is not long, and the degree of automation in the operation and control of units is not high. However, in future development, through constant searching for, summing up, and accumulating experiences, greater progress is bound to be made in unit work reliability, function of complete sets, economy, and unit seriation.

Tables

Table 1 Light Gas Turbines That Are Modified Versions of Aircraft Engines

Aircraft engine	Gas turbines that are modified versions of aircraft engines	Production unit	Progress status
WJ6	WJ6G1/1A	Nanfang Power Machinery Company, Zhuzhou City, southern Hunan Province	in production and use
	WJ6G2		can be put into production and use
	WJ6G2A/2C		in production and use
	409		in production and use
	WJ6G4		under development
WJ5	WJ5G	Harbin Aircraft Engine	in production and use
	WZ5G	Manufacturing Plant	in production and use

[continued on following page]

Table 1 [continued]

WP6	WP6G1	Liming Machinery Company, Shenyang City	in production and use
	WP6G1A		in production and use
WZ6	WZ6G		in production and use
	WS9G1	Xi'an Aircraft Engine Manufacturing Plant	in debugging use
WS9	WS9G2		under development
	WS9C3		under development
			under development

Table 2. Gas Turbines That Are Modified Aeronautical Versions in Finalized-Design Production

Model	Type	Production unit	Power kilowatts	Fuel	Year of design finalization
WZ6G	di axial	Lehe Machinery Plant	750	natural gas	1985
WJ5G	uni axial	Harbin Aircraft Engine Manufacturing Plant	1,250	natural gas	1984
WZ5G	di axial	Wuxi No 2 Machinery Institute	1,140	natural gas, kerosene	1977
WJ6G1	uni axial	Nanfeng Power Company	2,000	diesel oil, natural gas	1977
WJ6G2	di axial	Nanfeng Power Company	2,300	diesel oil	1981
WJ6G2C	di axial	Nanfeng Power Company	2,600	diesel oil	1984
409	di axial	China Shipping and Industry Gas Turbine Research Development Center, Nanfeng Power Company	2,600	diesel oil	1979
WP6G1	di axial	Liming Machinery Company	4,050	natural gas	1983
WP6G1A	di axial	Liming Machinery Plant	4,700	natural gas	1984

Table 3. Survey of Application of Gas Turbine Modified Aeronautical Versions

Model Designation	Gas turbine in use	Power kilowatts	Location of use
YD-2000 generating unit	WJ6G1/1A	2,000	Zhongyuan, Nanyang, Renqiu, Changqing, and Karamay oilfields
YD-1250 generating unit	WJ5G	1,250	Daqing Oilfield
3DR5 heating and power supply unit	WP6G1/1A	4,050 4,700	Daqing Oilfield
3DR5 water- pumping unit	WP6G1	4,050 4,700	Daqing Oilfield
WB-75 water- pumping unit	WZ6G	750	Zhongyuan Oilfield
WZ-5G water- pumping unit	WZ5G	1,140	fuel plants, Karamay Oilfield
WZ5G compressor unit	WZ5G	1,140	Zhongyuan Oilfield
DQ-1000 coal mine fire extinguisher	WZ5G		undergoing tests at Pingxiang Coal Mine
Hovercraft power	409	2,600	Navy
locomotive power	WJ6G2C	2,600	in test-generation

Table 4. Three Kinds of Gas Turbines That Use Modified Versions of the WSO Aircraft Engine

Model designation	Power in kilowatts (horsepower)	Use
WS9G1	4,420 (6,000)	industry
WS9G2	9,570 (13,000)	ship, industry
WS9G3	11,040 (15,000)	ship, industry

9727/9738

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NATIONAL DEVELOPMENTS

REGULATIONS ON AWARDS FOR TECHNICAL PROGRESS

OW130431 Beijing XINHUA Domestic Service in Chinese 0638 GMT 12 Jun 86

[Text] Beijing, 12 Jun (XINHUA)--Regulations on Awards for Rationalization Proposals and Technological Improvements

(Promulgated by the State Council on 16 March 1982)

(Revised and promulgated by the State Council on 4 June 1986)

Chapter I: General Principles

Article 1: These regulations are hereby put forth to promote the development of the national economy by encouraging workers and staff members, to improve their operation and management, and to increase the vitality of their enterprises.

Article 2: In these regulations, rationalization proposals refer to methods and measures for the improvement or perfection of production technology, operation, and management in enterprises and institutions; what is called technological improvement refers to improvements and innovations in machines, equipment, tools, technology, and other aspects.

The scope of the rationalization proposals and technological improvements is:

1. Improvement of the quality of industrial products and projects, improvement of the product mix, improvement and development of the variety of living things, and development of new products;
2. Greater efficiency in using and saving energy as well as raw and semi-finished materials and in making use of natural conditions;
3. Improvements in production technology, experiments, inspection methods, labor protection, environmental protection, safety techniques, medical and public health techniques, material transportation, storage, maintenance techniques, designing, statistics, and computer technology;
4. Improvement of tools, equipment, instruments, and installations; and
5. Popularization of scientific and technological achievements, devising

and application of managerial methods and means to modernize enterprises, and mastery, application, and development of imported technology and equipment.

Article 3: The principle of combining moral encouragement with material rewards shall be implemented toward those who make rationalization proposals and technological improvements.

Article 4: These regulations apply to state enterprises and institutions. Enterprises not owned by the state may give such awards in light of these regulations.

Chapter II: Award Standards and Methods

Article 5: Rationalization proposals or technological improvements made by workers and staff members (collectively or individually) can be awarded only after they are tested, studied, and applied in practice and have achieved results in the production or work of an enterprise or institution.

Article 6: Awards for adopted rationalization proposals and technological improvements whose economic benefits can be calculated are divided into five classes:

<u>Classes</u>	<u>Value of annual saving or value created</u>	<u>Amount of money award</u>	<u>Honorary award</u>
1.	Over 1 million yuan	2,500 to 4,000 yuan	certificate of merit
2.	Over 500,000 yuan and less than 1 million yuan	1,500 to 2,500 yuan	certificate of merit
3.	Over 100,000 yuan and less than 500,000 yuan	500 to 1,500 yuan	certificate of merit
4.	Over 10,000 yuan and less than 100,000 yuan	300 to 500 yuan	commendation
5.	Less than 10,000 yuan	less than 300 yuan	commendation

Rationalization proposals or technological improvements made by using applied scientific and technological achievements for reference that have achieved remarkable economic results should be awarded one class lower than the original.

What is termed "more than the figure" in this article includes the figure itself, and what is termed "less than the figure" does not include the figure itself.

Article 7: Corresponding classes of awards should be determined, in light of Article 6 of these regulations, for adopted rationalization proposals and technological improvements whose economic benefits cannot be directly calculated. In so doing, consideration should be given to the effects of such rationalization proposals and technological improvements, their complexity, and the scope of their popularization.

Article 8: Units accepting rationalization proposals and technological improvements that have been examined and determined to be kept as reserved technology should present the originators with awards within the amount of monetary award listed in Class 5 in accordance with these regulations; when such reserved technology is put into practical use, it should be awarded according to its economic results. When a monetary award is given after the application of such reserved technology, the amount of the monetary award originally issued should be deducted from the new monetary award.

Article 9: The value of annual savings or the value created by adopting rationalization proposals and technological improvements should be calculated by 12 months as a unit, beginning from the day of adoption; it should be examined and verified by the finance department of the adopting unit.

Article 10: New ideas put forward by engineers, technicians, or administrators after fulfilling their duties--ideas which are directly related to their work and have proven to be effective after being put to use--may be given awards in accordance with these regulations. Awards to factory cadres shall be reported to higher authorities for examination and approval.

Article 11: No proposal shall receive multiple awards. When a rationalization proposal or technological improvement project qualifies for two or more awards, it shall receive the higher award. If a proposal or an improvement project is deemed qualified for a higher award in the course of a reevaluation, it shall receive only the balance of the awards.

Article 12: When a rationalization proposal or a technological improvement project is submitted by a collective, the award it receives shall be distributed rationally among the members of the collective according to each individual's contribution.

Chapter III: Examination and Management

Article 13: Each enterprise and institution shall set up a committee or group to examine rationalization proposals and technological improvement projects. The administrative department shall be in charge of the committee or group, whose members shall include members of the trade union and relevant departments.

Article 14: Personnel of the relevant office or administrative department of an enterprise or institution shall promptly decide whether a rationalization proposal or technological improvement project shall be adopted.

They shall provide an explanation of their decision, which shall be referred to the relevant organs or personnel in written form, and to the evaluation committee or group, for examination.

Units shall, in accordance with regulations, promptly reward a rationalization proposal or technical improvement project it has adopted. Should a proposal or project not be adopted, they should explain the reason for it to whoever submitted the proposal.

Article 15: The grading of rationalization proposals and technological improvement projects should be examined and approved by the users. For Class 1 and Class 2 awards, the users, after approving them, should report their findings to the higher responsible departments for the record.

Article 16: The cost of financial awards shall be borne by the users. In an enterprise, the money it spends for awards shall be considered as part of the production cost; in an institution, the awards shall be defrayed from operating expenses, or by a percentage of the income it keeps.

Article 17: Rationalization proposals and technological improvement projects which have a relatively high economic value but cannot be used by the respective units shall be reported to, and handled by, higher responsible departments or provincial, regional, or municipal economic commissions (economic planning commissions). Proposals and projects of considerable economic value may be sold on the technological market.

Article 18: When a proposal or project for improving efficiency or reducing resources consumption is put into effect, the original quotas may continue to be maintained for a period of 6 to 12 months.

Chapter IV: Supervision and Settlement of Disputes

Article 19: The trade union and workers' congress of an enterprise or institution shall have the authority to supervise how these regulations are implemented. They may also ask the relevant departments for information about how the proposals have been handled, implemented, and awarded.

Article 20: The higher responsible departments shall supervise and examine how their subordinate units handle rationalization proposals and technological improvement projects; they shall be responsible for mediating in evaluation-related disputes in their affiliated enterprises and institutions.

Article 21: As for personnel who have won honors by means of deception, the unit that has meted out the award should retract the honors as well as the award. If the case is serious, it should also mete out disciplinary sanctions and investigate economic responsibilities.

Chapter V: Supplementary Articles

Article 22: The State Economic Commission shall be responsible for explaining these regulations.

Article 23: The State Economic Commission shall draw up detailed rules for implementation on the basis of these regulations. All enterprises and institutions shall draw up specific measures for implementation on the basis of these regulations and detailed rules, and report them to the higher responsible departments for the record.

Article 24: These regulations shall become effective upon their promulgation.

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CSO: 4010/64

NATIONAL DEVELOPMENTS

YOUTHS ENCOURAGED TO LEARN SCIENCE, TECHNOLOGY

OW250339 Beijing XINHUA in English 0105 GMT 25 Jun 86

[Text] Beijing, 25 Jun (XINHUA)--Fifteen of the 23 science and technology centers for youngsters, jointly built by the United Nation's Children's Fund (UNICEF) and the China Science and Technology Association, have been completed and put into use.

Meanwhile, three large-scale computer research centers are now underway in three Chinese cities--Hangzhou, Suzhou, and Qingdao.

Zhang Taichang, an official of the China Science and Technology Association said that these projects, which have the functions of training, service, research and demonstration, will provide 300 million Chinese youngsters with springboards for scientific and technological activities.

He said that the Chinese Government has been putting more emphasis on the promotion of science and technology among youngsters in recent years. The China Science and Technology Association has organized various extra-curricular activities to enrich the knowledge of primary and secondary school students.

Zhang Taichang of the association, who is in charge of the juvenile affairs, said that since 1982, about 4 million youngsters have participated in various scientific and technological activities organized by the association. Among them, 400,000 school students have learned to operate computers. At present, there are some 50,000 computers in use in primary and secondary schools, he said.

"Summer camps have not only broadened the horizons of the youngsters, but also created an ideal environment for their spare-time practice," he said.

According to Zhang, the association plans to organize 44 summer camps this year, with 45,000 youngsters participating. They have also invited Hong Kong and Japanese children to take part in these activities.

The Instructors' Association of Science and Technology for Young Pupils was established in 1981. The association now boasts a total of 400,000 members. Meanwhile, local governments have organized a number of scientific and technological groups in schools. In Shanghai alone, there are 3,131 such groups, with 115,000 participants.

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NATIONAL DEVELOPMENTS

SCIENTISTS BACK '100 SCHOOLS' POLICY IN ACADEMICS

OW271719 Beijing XINHUA in English 1514 GMT 27 Jun 86

[Text] Beijing, 27 Jun (XINHUA)--Two thousand leading scientists put their weight today behind the policy of allowing more freedom of ideas in the academic world.

The third national congress of the Chinese Association for Science and Technology, which ended here today, approved a resolution which called for the adoption of the policy of "letting 100 schools of thought contend" into the association's constitution.

The resolution also stressed the principle: "Economic development depends on the advancement of science and technology, and science and technology must serve economic development."

The association has agreed to report the views and demands of scientists and technicians to the Communist Party and government, and to defend their legitimate rights.

A work report by outgoing Association President Zhou Peiyuan was also approved at the meeting.

Newly-elected President Qian Xuesen said: "This meeting has developed democracy and strengthened unity among scientists and technicians."

Qian said Chinese scientific and technical workers were now mobilized to take part in the nationwide reforms, and to make great contributions to the country.

Government and party leaders attending today's closing session included Hu Qili, Fang Yi, Li Peng, Hu Qiaomu, Zhang Jinfu and Song Jian.

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CSO: 4010/64

NATIONAL DEVELOPMENTS

EFFECT OF ALLOCATION REFORMS ON COLLEGES DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 4, May 86 pp 8-10

[Article by Li Renhe [2621 0088 0735], and Tang Zhanqiu [3282 1455 3808] of the State Education Commission Science and Technology Office, and Cai Liyi [5591 4409 5030] of the Zhongshan University Scientific Research Office, and Que Weiming [7067 4850 2494] of the Jinan University Scientific Research Office: "The Effect of Reform of the Allocation System on Institutions of Higher Education"]

[Text] The S&T allocation reform is one of the pivots in the S&T system reform. "The Decision of the CPC Central Committee on S&T Reform," directed against the drawbacks of the S&T allocation system in the past, put forward a series of reform measures. The content of this document can be summarized in three aspects: 1) according to the characteristics of the different kinds of S&T activities, and methods such as public bidding, contracting, self-responsibility, funding and risk investment are to be adopted to implement classified management to provide reasonable financial resources for the different kinds of research; 2) longitudinal control is to be reduced, lateral relations are to be mediated and strengthened and the pressure and vitality of the S&T units for economic construction are to be increased to integrate S&T further with economic construction; 3) competitive allocation is to be implemented, S&T funding is to be linked up with the undertaken task, and the "iron ricebowl" is to be smashed. The implementation of this kind of reform is sure to have a profound and lasting impact on S&T undertakings in our country and in economic and social development, and it will promote education greatly.

I. Importance of Allocation System Reform

1. Spurring a Tighter Combination Between S&T and Economic Construction

In October 1982, Premier Zhao Ziyang initiated the strategic policy that economic vitalization must rely on S&T and S&T must be geared to economic construction. This national policy has had a great effect on the tighter combination of S&T with the economy. For a variety of reasons, the tendency toward disjunction between S&T and economic construction in our country has not been essentially reversed. In the enterprises, especially the large and

medium-size key enterprises, their desire to rely on S&T is not strong enough; even if some enterprises wish to rely on S&T, owing to the lack of capital to adopt some new technology or new products, often their ability falls short of their wishes. The S&T research units acquire their funding mainly from their superior departments and they can get by without being geared to the economy. Thus they too lack the vitality and pressure created by facing the economy.

The "Decision of the Central Committee of the Communist Party of China on S&T System Reform" was put forward to implement the system of combining a planned economy with market adjustment to let the enterprises make their own decisions and join in market competition. This will certainly and greatly increase the demand of the production units on S&T, thus increasing the momentum and pressure of the enterprises relying on S&T. The decision of S&T system reform also stipulates that the enterprises may distribute their technology development funds to the costs by stages and may apply to banks for technology development loans; in case of special need, the enterprise may draw an appropriate amount of money from their profits prior to taxation for their technology development fund, thus provides new channels of funding for enterprises relying on S&T. In an S&T organization, after the allocation system reform, the technology contract system will be implemented, step by step, in technology development work and application research which may gain some practical value in the short term. The research organizations engaged in this aspect will reduce, step by step, the operational funds appropriated by the state; requiring that, within 3 to 5 years, the majority will be able to support themselves with operational funds, thus forcing the S&T organizations of this kind to face the economy. Otherwise, they will not be able to survive, thus increasing the pressure on them. Therefore, after the economic reforms and the allocation system reform, it is possible for the enterprise to rely on the S&T fund, use economic measures, and spur their S&T research units to face economic construction. The S&T research units must also turn to the economy to solve the S&T problems for the enterprise in order to get funding for research and development, which will be an important source of S&T and economic construction can be closely combined, thus solving the problems of "targeting" and "relying on."

2. Spurring Reasonable Deployment in Various Research Activities

A reasonable proportional development among basic research, applications research, and technology development is an important guarantee to make S&T operate effectively on the economy and maintain this kind of effect, and it is also the important content of a state policy on S&T. In the past, owing to the lack of practical and effective measures, the structure of several kinds of research in our country has been maladjusted for a long time.

Those in charge of the S&T allocation system reform have decided to deploy classified guidance to different types of research. Technology development and applications research which may gain practical results in the short term are adjusted by the technology market and are transferred to become productive. Important S&T research listed in the state and local government plans, development projects, key laboratories, construction of test sites, public

utility research and S&T services, and fundamental technical work are allocated by the state. Advanced technology development with rapid change and high risk, and investments to start businesses, are allocated or granted as loans for control and adjustment to stimulate their growth. Basic research and part of the application research (i.e., retained for future use) are subsidized by the state science foundation to ensure their stable and continuous development. This kind of fund control adjusts not only technology development and practical short-term research but also other kinds of research activities. As long as we continue to analyze the effect of the funds actually being put in on economic construction and S&T development and practical short-term research but also other kinds of research activities. As long as we continue to analyze the effect of the funds actually being put in on economic construction and S&T development, and draw on the experience of other countries, an S&T structure conforming to the reality of our country and to modernization construction may be established gradually.

3. Ending the Separation of the Five Front Armies and Departmental and Local Ownership

After the founding of the country, our government assembled the S&T forces, organized and established the huge national and provincial academies of sciences and the S&T research system of national defense and military engineering. Thus there emerged a S&T troop including the five systems of the Chinese Academy of Sciences, the industrial departments in the central government, the industrial departments in local governments, national defense, and military engineering, and colleges and universities. These systems have during a certain period of time played a positive role on some urgent tasks for the state. However, viewing the five systems as a whole, each did things its own way and had a style of its own, thus resulting in serious dispersion and redundancy in the establishment of the S&T mechanism and research items. It is difficult to coordinate and is disjointed from the economic structure; the state allocated funds according to administrative jurisdiction and each department and local government managed according to the departmental and local systems of ownership, resulting in discouraging the enthusiasm of some of the S&T personnel.

This drawback was long since spotted by the various authorities. After the 3d Plenum of 11th Party Central Committee, the state Science Commission tried to adjust the deployment of the S&T research mechanism in our country but owing to departmental and local ownership, the results were very few and it became a chronic and stubborn disease in the S&T system of our country.

Scientific research institutions are academic research units and they hope to have true autonomy in academic research while one of the things that greatly affects the autonomy of academic research is funding control from the top. The S&T allocation system reform has changed the relationship between the S&T research units and their superior authorities and they can break the bond of the five sources and departmental and local ownership in order to be more autonomous in being geared to face society.

4. Effectively Spurring Internal Reforms in Research Institutes

The allocation system reform has weakened longitudinal control and strengthened latitudinal relationships, expanded the autonomy of the research units, and provided the research units with conditions for reform. The allocation system reform spurs S&T research to face society and join the competition. Thus there can be force and pressure for internal reform.

The competitive allocation system reform smashed the "iron ricebowl" in which the institutes eat from the state and individuals eat from the institutes. Thus it forces the S&T institutes and the S&T personnel to increase their efficiency and improve their professional skills and to gain more and better results to strive for survival and growth in the competition. To survive in the competition, the research institutes and the colleges and universities must change their inappropriate management, organization, and personnel systems; besides, they must adjust the direction of research and targets for a topic and strengthen relations and coordination among the different disciplines within to develop overlapping disciplines. Without reform, the S&T units can hardly survive and only through reform can the various problems which exist in the research units be solved; these problems are disadvantageous to contract work in research. Only then can the enthusiasm for invention and creation by S&T personnel be encouraged, the bond of the original system be broken, and the initiative taken to face the economy.

II. Measures To Be Taken by the Universities To Meet the Allocation Reform

1. Replace Inappropriate Old Concepts and Establish New Ones To gear to the Economy.

There is a problem of concept and thought transformation in the higher education system reform. For example, there exist different understandings of the words "schools of higher education should take teaching as their principal mission," "S&T research must serve teaching," "colleges and universities must be both the center of education and the center of S&T research," etc. In S&T research work in the universities, there is in general a shortage of concepts of market, competition, and economic results. In rewarding accomplishments and making job promotions, there exist a grave egalitarianism and a concept of seniority based on years of service.

In our opinion the concept that universities should take teaching as their principal mission is lopsided. To cultivate higher-level specialists and to promote S&T education are the two basic assignments for schools of higher education; scientific research and teaching are both important measures to cultivate high-level specialists. Without high-level scientific research there will be no talent of high quality cultivated. Full utilization of the intellectual resources, the academic environment, and the laboratories of the universities has a profound significance in the promotion of the scientific education and the modernization of construction in our country. Besides, one investment can yield two kinds of interest: technology results and talented people, which are also cost-efficient.

In schools of higher education, the prejudice of despising the work of technology and development is deeply rooted. For example, people engaged in technology work are looked upon as inferior to others and technological inventions are considered "worthless" or "substandard." In the assessment of titles and promotions, technology development usually is not used as a basis, resulting in many people not wanting to engage in technological work or not wanting to be assessed with a S&T title. Therefore, for a long time, in the work of S&T research in the schools, teachers were only satisfied with publishing articles and writing and had little interest in applied research with economic results, were not willing to do development research, had little enthusiasm for promoting the application of new technology or products, and even more were unwilling to go to the factories or enterprises to do S&T development or promote the results. Personnel in the field of technology in the universities are few, their quality is not high, and the structure of the personnel is not reasonable.

Therefore, we must have a correct understanding of the mission of the schools of higher education and change the thought of despising technological work among the leading cadres and the teachers, staff, and workers and establish a strong technology system in the schools and encourage teachers, staff, and workers to solve technological problems of economic construction, especially the problems of high technology. We must establish the general mood of valuing technology and development and strive for economic and social results. In every piece of research work, we should establish the thought of serving economic construction. This spirit should also be adhered to in basic research and applied research; we must pay attention to promoting basic research with future applications and applied research which can promote development ability. We must provide necessary theoretical reserves for economic construction and the S&T growth of our country to ensure the after-effects of economic and S&T growth.

2. Start with Reality and Division of Labor, Play Exemplary Role in Different Fields and Levels.

In schools of higher education, especially in the science colleges of universities, scientific researchers should regard basic and applied research as their principal work. To coordinate with the national S&T allocation system reform, research institutes of various levels must be readjusted. Colleges and universities should take the initiative to accept assignments from industrial departments and enterprises, especially large and medium-size key enterprises, and take their solution of important S&T problems in economic construction as the important assignments of their S&T research. Various schools of higher education should be based on the reality of the state and the region and start with the needs of economic construction to select their topics for research. With high-tech, difficult, or labor-intensive items, items requiring coordination with related disciplines, state-run items, items of application and technical development research targeted at economic construction, items for absorption and digestion of introduced technology, applied technology targeted at medium-size and small-enterprises (i.e., "short, appropriate, and quick" technology) and various

kinds of research at different levels of difficulty and with different quality requirements, the schools should choose according to the nature of the school, direction of development, the purpose of the education, and the strength of their research force to take advantage of their own superiorities.

3. Stress the Fundamentals and Application, Maintain the Aftereffects of Technology Development.

Universities, while carrying out the policy of gearing to the economy and stressing technology development, should appropriately arrange their basic and applied research. Among the several S&T ranks, universities should share more responsibility for basic research to achieve greater results. Universities have the responsibility to cultivate advanced specialists and their basic research must maintain a certain proportion and continue to develop steadily. Research in the universities in the past did not have clear goals in application, nor any further development with their research results; the related departments and the enterprises paid no attention to the results of the applied research in the universities, therefore, the ratio in technical-results application and the economic results were both low. To alter this situation, universities must aim at the important technological problems of economic construction and the enterprises and use basic theories to guide and promote applied research. Thus technology development in the universities is both built on the foundation of economic construction and able to use basic research as its backing, with a higher starting point, to keep the technology development going on.

4. Unite To Join the Competition

To promote strength for competition, universities should unite their strengths, based on the needs of the practical assignments or the trend of development of that discipline, to strengthen lateral relations among the various disciplines and to establish cooperative research groups on certain topics, comprehensive research and development centers and consulting service centers, interdisciplinary S&T cooperative committees, and various cooperative organizations to give full play to the superiority of the universities in their many disciplines. Unite together and do well in the organizing and coordination work, the superiority will manifest itself, and it will be easy to solve the important comprehensive technological problems. So the universities, the disciplines in a university, the universities, the industrial departments, and the enterprises must have connections and be united. Since 1979, in and out of the organization department of the Ministry of Education, the coordination group established by the seven universities has accumulated beneficial experience in contracting the projects of the Shanxi and Nei Monggol remote-sensing technology application and reinforced the concrete multipurpose platform in the Nanhai oil field development. They are the successful examples of cooperation among universities in contracting important assignments of the state.

5. Stress Key Discipline on Establishment of Key Laboratories, Create open Bases of Teaching and S&T Research.

To increase the ability of the research forces in the universities to cultivate specialized talent of high quality, we must step by step and with a plan establish in the universities a group of key disciplines with a reasonable structure of classification. The key disciplines aim at taking the lead as examples in the promotion of the quality of education and academic standards to be able to solve the important S&T problems in economic construction and social development to provide scientific bases for important decision making for the state. These key disciplines are the key bases for laboratory scientific research and talent cultivation. We must strive for support from the related departments of the state and the local governments, raise funds through the different channels such as contracting assignments, technology developments, and management, and strengthen the establishment of laboratories with a plan. Besides, we must establish a strong contingent of laboratories to give full play to the utilization and efficiency of the instruments. We must take the initiative to create conditions for the key laboratories to implement, step by step, opening up to a different extent and to give full play to the positive role of teaching and S&T research within and outside the universities.

The allocation reform will create competition among the universities and the departments in a university and among the research institutes. This competition will spur the universities, departments, and institutes to take the initiative to concentrate their own forces to take effective measures to meet the demands of economic development. Some of the universities will improve step by step and raise their standards, and their proportion of scientific research will increase and they will have a better connection with economic construction to become universities of research in style, which are mainly for scientific research and for cultivating specialized talent of a higher standard.

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PHYSICAL SCIENCES

INTERFACE DEFECTS IN LPE $\text{Ga}_x\text{In}_{1-x}\text{P}/\text{GaAs}(100)$ OBSERVED

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 2, Mar 86 pp 222-225

[Article by Chen Jie [7115 2638], Fundamental Physics Center, China University of Science and Technology, Liang Jingguo [4731 7234 0948], Yu Lisheng [5713 7787 3932], and Liu Hongxun [0491 1347 8113], Department of Physics, Beijing University: "Observation on the Interface Defects in LPE $\text{Ga}_x\text{In}_{1-x}\text{P}/\text{GaAs}(100)$ by TEM," received 1 February 1985]

[Text] English Abstract: Plane-section, cross-section, and angle-lapped specimens of LPE $\text{Ga}_x\text{In}_{1-x}\text{P}/\text{GaAs}$ were prepared. The defects at interface were examined and analyzed by TEM. Burgers vectors of most dislocation lines at interface are $b = \frac{1}{2}(110)$. Dislocation lines in plane-section specimens are bent and form dislocation network. Dislocation lines in cross-section specimens are straight and discrete, with no network formed. A new model of dislocation generation in LPE growth $\text{Ga}_x\text{In}_{1-x}\text{P}$ layers is proposed to account for the dislocation distribution. It is believed that the inclusion introduced during growth is the main source of dislocations in the epitaxial layers. It is concluded from the observation of the angle-lapped specimens that dislocations propagate from substrate into epitaxial layers by bending and surface generation mechanism.

I. Introduction

In recent years, $\text{Ga}_x\text{In}_{1-x}\text{P}$ has aroused great interest in research on semiconductor photoelectric materials. 300K, $x = 0.74$, $E_g \sim 2.25\text{eV}$ is one of the materials in current reports which has the broadest direct gap¹. In the epitaxial growth process, defects of various shapes can be introduced inside the crystal. Experiments show that interface defects have a clear influence on the semiconductor components. The researches of Hutchinson², Woolhouse³ and others using transmission electron microscopes have proven that the dark lines (DLD) created by heterostructure laser degeneracy are a network of dislocation formed by the dislocation dipole, and are developed and formed by the initial penetration of dislocation in the crystal in the process of being excited by light. Merne⁴, Matthews⁵ and Abrahams⁶ have studied theoretically, the laws and forms created by mismatch dislocation on epitaxially grown interfaces and analyzed nucleation and growth and the slip and climb mechanisms of mismatch dislocations on interfaces. Booker⁷ used an electron microscope to

study the laws and forms generated by dislocation in semiconductor epitaxially grown layers and pointed out the mechanisms which formed mismatch dislocation. This paper uses ultrahigh pressure electron microscope to observe and analyze the characteristics of dislocation distribution in the vicinity of the interface in different specimens and proposes a model of dislocation generation in GaInP liquid epitaxial growth and believes that the primary source of dislocation in epitaxial layers is impurities on the substrate surface and in the mother liquor; we discover that the dislocation in the substrate is expanded outward toward the epitaxial layer by the bending and surface generation mechanism.

II. Experiment

The experiment specimen was a GaAs/Ga_xIn_{1-x}P ($x = 0.4-0.5$) single heterostructure, the epitaxial layer was grown using customary liquid epitaxial technique on a GaAs substrate oriented (100). The substrate thickness was 300 μm , the growth temperature was 777°C, the epitaxial layer thickness was 3-6 μm . Plane-section, cross-section and angle-lapped specimens refers to the specimen observation surface as parallel to, perpendicular to or oblique to the growth interface. We first used mechanical grinding to thin the specimen to 30 μm , then prepared the TEM specimen through hydro-chemical corrosion, the protectant was lanolin, the corrosive was Br₂-CH₃OH. The instrument used for observation was a TEM-1000 transmission electron microscope, the accelerated voltage was 1000kV.

III. Experiment Results and Discussion

In epitaxial growth, the dislocation in the epitaxial layer can be induced by the following ways:

- 1) Expansion of the substrate dislocation; 2) collective growth of impurities in the growth process; 3) coalescence of spot defect to form a dislocation ring; 4) plastic deformation in the growth, cooling, and removal process; 5) mismatch dislocation created by mismatched stress introduced by crystal mismatch.

Figure 1 (see Plate I) is a topographic image of dislocation of the plane-section specimen, the extinction diffraction dingchu [1353 0427] dislocation line Burgers vector $b = \frac{1}{2}(110)$. From the figure it can be seen that most of the dislocation lines appear paired, and their interweaving forms a dislocation network. The factors which caused this may be the impurities. Since initially there were some impurities on the growth surface (the substrate surface), after the substrate and the mother liquor came in contact, the places where there were impurities were sites for nucleation first, and in the growth process, the dislocation lines which grew interwove to form a dislocation network. From Figure 1 it can be seen that the dislocation lines are linked to a black dot (A dot), which may be impurities, and thus we feel that this is support for the above described model. The very regularly curved dislocation line of the border in Figure 2 (see Plate I) is not due to the corrosion thinning process nor is it strict parallel growth interface thinning, but is produced at an angle, AB is the epitaxial interface, its may come from

the surface generation mechanism provided by the lower surface. (a) in Figure 3 is the surface generation mechanism, with the action of mismatch stress, dislocation within the epitaxial layer surface nucleates and along with the continuation of the epitaxial process it moves toward the epitaxial layer; (b) is the bending mechanism, the initial penetration dislocation is bent by the stress at the interface, and the result is that there is dislocation at the interface but there is none within the epitaxial layer; (c) is the bending and surface generation mechanism, near the interface the place where the penetration dislocation is exposed a new dislocation is generated due to the action of stress, the dislocation generated and the original dislocation at the interface bend in opposite directions and form two sections, and they continue to expand in the epitaxial layer as epitaxis continues. Figure 4 (Plate I) is the angle-lapped specimen. At the place indicated by the arrow it can clearly be seen that the substrate dislocation is expanding into the epitaxial layer, and one branch, crotch-like becomes two, its forming mechanism is the bending and surface generation mechanism described above⁷. From this it can be seen that the bending and surface generation mechanism is the primary mechanism for the substrate dislocation to expand into the epitaxial layer.

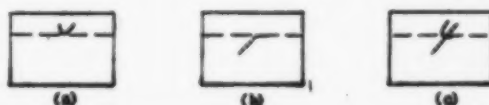


Figure 3. Diagram of Bending and Surface Generation Mechanism

Figure 5 is the cross-section specimen (Plate I). Comparing it with the plane-section specimen, one can see that there is no interwoven dislocation network in the cross-section specimen, the dislocation lines are straight and basically arranged in the same direction. The generation of this type of discrete dislocation line can also be explained by the impurity generation mechanism discussed above. Due to the impurities on the growth surface, after contact with the mother liquor, just as the mother liquor passes over the impurity, due to surface tension action, first of all a single epitaxial layer coagulates on the impurity surface, and in the coagulation process, the impurity surface nucleates to generate a dislocation, and as the epitaxis continues, the dislocation continues to expand. Most of the dislocation lines are arranged in the same direction which indicates that in the epitaxial growth process, the dislocation has a preferred growth direction. In addition, in Figure 5 we can see that the dislocation line is associated with a black dot, which fits with the above described mechanism.

IV. Conclusion

Through transmission electron microscope observation of the plane-section, cross-section and angle-lapped specimens and analysis of the characteristics of dislocation distribution in comparable epitaxial layers, we obtain the following conclusions:

- (1) The Burgers vector of the dislocation lines observed was b averaged $\frac{1}{2}(110)$.

(2) Dislocation line in the plane-section specimen bent and interwove to form a dislocation network; the dislocation lines in the cross-section specimen were straight and did not form a network. Analysis recognized that in $\text{In}_x\text{Ga}_{1-x}\text{P}$ LPE growth, the primary source of dislocations in the epitaxial layer is impurities in the substrate surface and mother liquor, and in the epitaxial process, the dislocations produced because of this continue to expand and propagate and under thermal stress move to form a dislocation network. Therefore, the cleanliness of the substrate surface is of utmost importance in growing epitaxial layers properly and this fits with the results of actual epitaxial growth experiments⁹.

(3) The substrate dislocations observed in the angle-lapped specimen was expanded into the epitaxial layer by bending and surface generation mechanisms, therefore reducing the density of dislocations in the substrate is an important technique for improving epitaxial chip quality.

(4) No mismatch dislocation networks produced by mismatch stress were observed in the epitaxial layer, this means that the crystal lattice of the specimens used was well matched.

REFERENCES

1. A. Onton, M.R. Lorenz, and W. Reuter, J. APPL. PHYS., 42, 3420 (1971).
2. P.W. Hutchinson and P.S. Dobson, APPL. PHYS. LETT., 26, 251 (1975).
3. G.R. Woolhouse, B. Monemar, and C.M. Serrano, APPL. PHYS. LETT., 33, 94 (1978).
4. J.H. Van der Merne, J. APPL. PHYS., 41, 4725 (1970).
5. J.W. Matthews, EPITAXIAL GROWTH PART B ACADEMIC, New York, 1975.
6. M.S. Abrahams, L.R. Weisberg, C.J. Buicchi, and J. Blanc, J. MATER. SCI., 4, 223 (1969).
7. G.R. Booker, J.M. Titchmarsh, J. Fletcher, D.B. Darby, M. Hockly and M. Aljassim, J. CRYST. GROWTH, 45, 407 (1978).
8. G.R. Woolhouse, A.E. Blakeslee, and K.K. Shih, J. APPL. PHYS., 4, 4349 (1976).
9. Chen Jie [7115 2638], BEIJING DAXUE BOSHI BIYE LUNWEN [M.A. THESIS, BEIJING UNIVERSITY], 1978.

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PHYSICAL SCIENCES

MONTE CARLO METHOD USED TO STUDY SENSITIVITY OF V_T IN SHORT CHANNEL MOSFET

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[Article by Zhao Honglin [6392 7703 7792], Department of Electrical Engineering, Tianjin University: "Monte Carlo Study of Sensitivity of V_T in Short Channel MOSFET"; received 24 February 1985]

[Text] English Abstract: Monte Carlo method has been used to study the sensitivity of V_T to SiO_2 thickness t_{ox} , charge density of surface state Q_{ss} , substrate impurity density N_A , channel length L etc., while the transistor's geometry and process parameters varying practically. The dispersion of V_T is also studied. Results show that when L enters short channel region, the sensitivity of V_T to L increases rapidly while to t_{ox} , Q_{ss} , and N_A it decreases. The distribution of V_T is normal.

I. Introduction

Using the Monte Carlo method to carry out component processing simulation can predict, the average values and distribution of output component parameters from the wave range of the input variables of raw materials, dimensions, and processing parameters. Furthermore, in a large number of input variables, it can also distinguish the primary and secondary factors that cause output parameter dispersion¹.

After a MOSFET's L drops to a certain value, V_T is no longer only a function of N_A , t_{ox} , and Q_{ss} , but also is related to L , channel width w and the source-drain junction depth γ_j . This paper uses the Monte Carlo method to study the above characteristics.

The sensitivity of the output parameters is a function of an input variable's wave on its dispersion. This work studies the changes in V_T on the sensitivity of variables when L is gradually shortened.

II. Simulation Method

After the dimensions of a MOSFET are reduced, the expression of V_T is²:

$$V_T = \phi_{ms} - \frac{Q_{ox}}{C_{ox}} + 2\phi_F + \frac{Q_B}{C_{ox}} \times \left\{ 1 - \left[\left(1 + \frac{2W_D}{\gamma_j} \right)^{1/2} - 1 \right] \left[\frac{\gamma_j}{L} + \frac{2W_D \gamma_j}{WL} \right] + \frac{2W_D}{W} \right\}. \quad (1)$$

in which ϕ_{ms} is the metallic semiconductor power coefficient difference. $C_{ox} = \epsilon_{ox}/t_{ox}$ is the unit surface area oxidized film capacitance. ϕ_F is the Fermi force of the substrate. $Q_B = (4q\epsilon_s N_A \phi_F)^{1/2}$. W_D is width of the depletion layer when the substrate offset voltage is zero, $W_D = W_x$. In equation (1), V_T is the function of the six variables: t_{ox} , Q_{ss} , N_A , L , W , and γ_j .

The average values of the six input variables and the root-mean-square difference are selected with reference to the actual situation. The rise and fall of the actual variables in the vicinity of their average values is normal distribution. Six groups of standard normal distribution random numbers are produced, then are converted into normal distribution of the variables. Substituted in (1) V_T is calculated. Each group in this task has 1000 random numbers. Recomputing 1000 times arrives at 1000 V_T .

The sensitivity S of V_T is defined as³:

$$S = \left(\frac{\text{output distribution width when a single input variable changes X 95\%}}{\text{output distribution width when each input variable changes X 95\%}} \right)^2 \times 100\% \quad (2)$$

The numerator in equation (2) is the change of an input variable, when the other items are fixed in average values, the distribution width of V_T is broader. The denominator is the distribution width of output V_T when all the input variables change. The two xiangchu [4161 7110] represent the relative contribution of changes in the variable with regard to the V_T distribution. It is expressed in percentages.

By selecting different average values for L and recalculating equation (2) one can get the sensitivity S of V_T with regard to different variables as L changes.

III. Conclusion and Analysis

The average values and standard deviation of the six input variables are taken in accordance with actual circumstances. $t_{ox}(\text{\AA}): 500, 20$; $N_A(10^{16}\text{cm}^{-3}): 6, 1$; $Q_{ss}(10^{11}\text{cm}^{-3}): 2.5, 0.2$; $\gamma_j(\mu\text{m}): 0.5, 0.03$; $W(\mu\text{m}): 10, 0.3$; $L(\mu\text{m}): 0.7-4, 0.15$.

Table 1 is the sensitivity S of V_T to variables when L is different. As L changes, the sensitivity of the variables changed. Figure 1 is the curve drawn from the data of Table 1. The horizontal axis is L and the vertical axis is S . Each curve represents the S of V_T to that variable as L changes. The S of V_T to γ_j and W is nearly zero, and these two curves are not drawn in Figure 1.

Table 1. Sensitivity $S(X100\%)$ of V_T to Variables When L Is Different

$L(\mu m)$	0.7	0.8	0.9	1.0	1.25	1.5	2.0	3.0	4.0
S									
$S(N_A)$	0.01	0.02	0.03	0.04	0.05	0.05	0.05	0.05	0.05
$S(t_{ox})$	0.10	0.19	0.27	0.33	0.42	0.46	0.49	0.52	0.53
$S(Q_{ss})$	0.13	0.22	0.31	0.36	0.43	0.44	0.44	0.44	0.44
$S(r_f)$	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0
$S(W)$	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0
$S(L)$	0.76	0.57	0.39	0.27	0.11	0.05	0.01	~ 0	~ 0

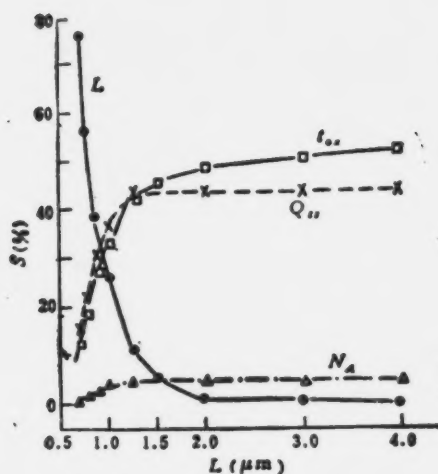


Figure 1. Sensitivity S of V_T to Variables With Changes in L

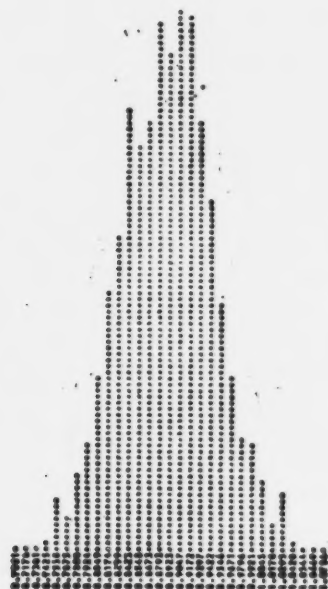


Figure 2. V_T Distribution

Figure 2 is a distribution chart of 1000 V_T s when $L = 1.25 \mu m$ and the six variables change simultaneously. In the figure, $(V_T)_{min} = 0.7051 V$, $(V_T)_{max} = 1.0794 V$. The actual average value is $0.8833 V$. This figure shows that the V_T distribution is close to normal distribution. The standard deviation is calculated at $0.0569 V$.

The above results show:

- (1) The criterion equation for short channel effect is⁴:

$$L_{min} = 0.4[\gamma_i t_{ox}(W_s + W_d)^2]^{1/3}. \quad (3)$$

in which W_s and W_d are the potential width of the source and drain, respectively. Substituting the data used in this article we get $L_{min} = 1.7 \mu m$.

Due to the sensitivity of V_T to L [Table 1], at about $L = 2.0 \mu m$, the short channel effect begins to appear. This is close to the results of criterion equation (3).

(2) When $L > 3 \mu m$, the S value of V_T to L is close to zero. The value for t_{ox} and Q_{ss} is higher. After L drops to $1.5 \mu m$, the S value of V_T to t_{ox} , Q_{ss} and N_A clearly declines, and L 's S value rises sharply. This shows that the short channel effect is reflected in the sensitivity S .

(3) The distribution of V_T is normal. Therefore, component simulation using the Monte Carlo method can predict the rate of finished components.

REFERENCES

1. A.R. Alvarez and L.A. Akers, ELECTRONICS LETTERS, 18, 42 (1982).
2. L.A. Akers, SOLID-STATE ELECTRONICS, 24, 621 (1981).
3. C.H. Stepper and P.B. Hwang, SEMICONDUCTOR SILICON, pp 955-967 (1977).
4. S.M. Sze, PHYSICS OF SEMICONDUCTOR DEVICES, pp 469-473, 2nd, (1981).

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PHYSICAL SCIENCES

CHARACTERISTICS OF BORON, ARSENIC DOUBLE IMPLANTATION IN SILICON STUDIED

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[Article by Ma Yi [7456 6146], Li Guohui [2621 0948 6540], and Zhang Tonghe [1728 6639 0735], Low-Energy Nuclear Physics Institute, Beijing Normal University, and Huang Chang [7806 2412], Li Shan Microelectronic Company: "Measurement of the Carrier Profile of Boron and Arsenic Double Implantation in Silicon and Its Simulation"; paper received on 8 February 1985]

[Text] English Abstract: The characteristics of boron and arsenic double implantation in silicon are studied and the interaction between these two elements are discussed. An exponential decreased electrical field is used to simulate the dip of base carrier profile near E-B junction and an effective diffusivity is used to simulate the effect of enhanced diffusion in the tail region. A computer program is made to calculate the carrier profile of boron and arsenic double implantation in silicon.

I. Introduction

With the development of LSI and VLSI, ion implantation technology has received serious attention more and more. People must understand the boron and arsenic implantation and the laws of carrier distribution after thermal annealing in bipolar components to provide information for circuit designers.

II. Experiments in Boron and Arsenic Double Implantation Carrier Density Distribution, Results and Analysis

A. Experimental Method

The experimental material was P<111>, a substrate of resistance 8-13 Ω ·cm grown 5-6 μ m thick and an n-type epitaxial layer of resistance 0.35-0.40 Ω ·cm. Boron and arsenic were the base area and the emitter dopant, respectively. To avoid a 7° sample angle at channel implantation time, after some of the sample was implanted with boron, when the arsenic was implanted, aluminum foil was used to shield a part. After the sample had been manufactured, the differential conductance method was used to measure the carrier concentration distribution. A DT-830 digital multimeter was used to measure the current, with a precision of (reading + three times the floating point number) X 1.0

percent, a voltage was measured with a DME-1400, with a precision of 0.04 percent $\times$ the reading + 0.02 percent $\times$ the measuring range, the measuring range was 200 mV, a TP-77 tuopianyí [2900 0252 0308] was used to measure the SiO_2 film thickness, with a precision of $\pm 20 \text{ \AA}$, and digital processing was carried out by a computer.

B. Experimental Results and Analysis

1. Comparison of Boron Single Implantation and Boron and Arsenic Double Implantation

In Figure 1 one can see that the base region carrier concentration dips in the vicinity of the E-B junction which can be accepted as the result of internally constructed electrical field action. In the high temperature thermal annealing process, after the implantation ions have been activated, the donor ions carry positive charge, and because the mass of the ions is many times greater than the carrier, the carrier always diffuses faster than the ions. However, due to the demands of local electricity neutrality, the existence of the ions also suppresses the diffusion of the carrier, and this creates an internally constructed electrical field. This electrical field accelerates the diffusion of the donor into the silicon and suppresses the diffusion of the acceptor, because after the acceptor is ionized, it carries a negative charge. In Figure 2, the peak position distance of the E-B junction is farther and the dip is not severe since the boron implantation energy is high.

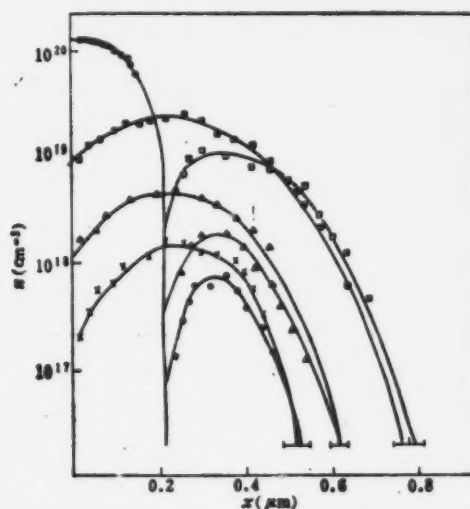


Figure 1. Comparison of Carrier Concentration Distribution of Boron Single Implantation and Boron-Arsenic Double Implantation
 Boron single implantation 70keV, 1000°C, 30' annealing,
 ■ $1 \times 10^{15}/\text{cm}^2$, ▲ $2 \times 10^{14}/\text{cm}^2$, × $6 \times 10^{13}/\text{cm}^2$,
 Arsenic implantation 80keV, $2 \times 10^{15}/\text{cm}^2$,
 Boron double implantation □ $1 \times 10^{15}/\text{cm}^2$, Δ $2 \times 10^{14}/\text{cm}^2$, ○ $6 \times 10^{13}/\text{cm}^2$

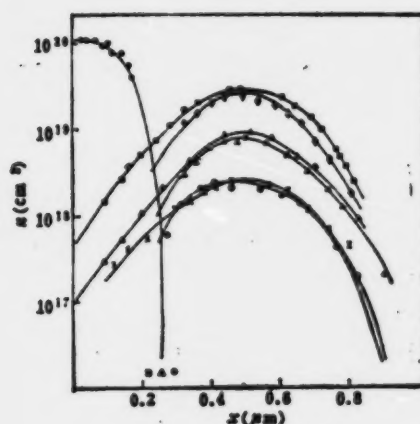


Figure 2. Influence of Different Implantation Dosages of Boron
 Boron single implantation, 160keV, 950°C, 30' annealing,
 ■ $1 \times 10^{15}/\text{cm}^2$, ▲ $2 \times 10^{14}/\text{cm}^2$, x $6 \times 10^{13}/\text{cm}^2$,
 Dual implantation: ● Arsenic implantation 80keV, $2 \times 10^{15}/\text{cm}^2$,
 Boron: □ $1 \times 10^{15}/\text{cm}^2$, Δ $2 \times 10^{14}/\text{cm}^2$, o $6 \times 10^{13}/\text{cm}^2$

2. Influence of Different Boron Implantation Dosages

In Figure 2 we can also discover that as the boron implantation dosage increases, the entire distribution of the base region translates upwards, and at the same time since the donor and acceptor compensation increases making the emitter region concentration dip, and the E-B junction become shallower.

3. Influence of Different Implantation Sequences

In Figure 3 we can see that the differences between the two 950°C+1000°C annealings and the one 1000°C annealing are not great. The two curves basically overlap, but there is a broader base region than the single 950°C annealing. For the sample in which the As was implanted first and the B implanted afterwards, since there was 30' annealing at 1000°C after the As was implanted, the E-B junction is already rather deep, and more of the boron is located below the emitter region, and added to the fact that the annealing temperature is also low, it leads to a rather thin base region.

4. Influence of Double Implantation on B-C Junction Depth

Figure 4 is an angle lap stain microscopic photograph enlarged 800 times, and one can see that the double implanted region is level with the bottom of the boron single implantation region boundary. It can be seen that under the technological conditions demanded by components in general, the influence of implantation of the B-C junction can be overlooked.

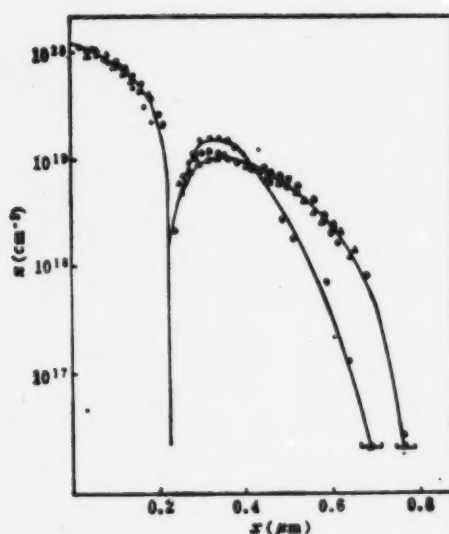


Figure 3. Comparison of Different Implantation Sequences

- ▲ B⁺950°C, 30' + As⁺1000°C, 30'
 - B⁺ + As⁺1000°C, 30'
 - As⁺1000°C, 30' + B⁺950°C, 30'
- B⁺ implantation 70 keV, $1 \times 10^{15}/\text{cm}^2$
 As⁺ implantation 80 keV, $2 \times 10^{15}/\text{cm}^2$



Figure 4. Influence of Double Implantation on B-C Junction
 Boron 70 keV, $2 \times 10^{14}/\text{cm}^2$ + As⁺80 keV, $5 \times 10^{15}/\text{cm}^2$, 1000°C, 30'

III. Computer Simulation

A. Simulation of Emitter Region Carrier Distribution

We used Fair's¹ method. The impurity concentration after arsenic implantation could be expressed using Chebyshev's equation:

$$N/N_0 = 1.00 - 0.87Y - 0.45Y^3. \quad (1)$$

For ion implantation samples, conditions of implantation dosages below $5 \times 10^{15}/\text{cm}^2$ require only 1000°C , 20' annealing to achieve a 100 percent activation rate^{2,3}, therefore equation (1) can be viewed as an approximate emitter region carrier concentration distribution.

B. Simulation of Base Region Carrier Distribution

An exponential decay field can be used to simulate the internally constructed electrical field of the E-B junction. The ion flow when there is an external force field is:

$$J = -D \frac{\partial N}{\partial x} - e \mu N s_x. \quad (2)$$

We suppose

$$s_x = s_{\max} e^{-\left(\frac{x-s_k}{l}\right)}. \quad (3)$$

On the basis of the relationship between the experimental curve simulated $s_{\max, \lambda}$ and the technological conditions, we can extend it to a broader range.

IV. Circuit Applications

1. High speed ECL circuits (created in cooperation with the Computer Institute of the Chinese Academy of Sciences)

B⁺ implantation 10keV, $2 \times 10^{12}/\text{cm}^2$, 20keV, $6 \times 10^{12}/\text{cm}^2$, 40keV, $1 \times 10^{13}/\text{cm}^2$, 60keV, $6 \times 10^{13}/\text{cm}^2$, 850°C , 30' annealing, As⁺ implantation 80keV, $5 \times 10^{15}/\text{cm}^2$, 1000°C , 25', $\beta = 20-40$, $V_{CE} = 14\text{V}$, $V_{EB} = 4-6\text{V}$.

2. TTL circuits (created in cooperation with the Li Shan Microelectronics Company)

B⁺ implantation 60keV, $6 \times 10^{13}/\text{cm}^2$, 960°C , 30', As⁺ implantation, 80keV, $5 \times 10^{15}/\text{cm}^2$, 1000°C 20', $\beta = 100$, $V_{CE} = 10\text{V}$.

3. LS-TTL circuits and L-TTL circuits (created in cooperation with the 109 Plant of the Chinese Academy of Sciences)

B⁺ 60keV, $8 \times 10^{14}/\text{cm}^2$, 950°C , 30', As⁺ 80 keV, $5 \times 10^{15}/\text{cm}^2$, 1050°C , 30', $\beta = 10$, $V_{CE} = 25\text{V}$, $V_{BC} = 35\text{V}$, $V_{EB} = 6\text{V}$.

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REFERENCES

1. R.B. Fair, J. APPL. PHYSICS, 43, 1278 (1972).
2. R.B. Fair and J.C.C. Tsai, J. ELECTROCHEM. SOC., 122, 1689 (1975).
3. R.O. Schwenker, E.S. Pan, and R.F. Lever, J. APPL. PHYS., 42, 3195 (1971).

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PHYSICAL SCIENCES

INTERFACE REACTIONS, VACUUM ANNEALING EFFECTS OF MBE Al/GAAS

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[Article by Zhong Zhantian [6988 2069 1131], Chen Zonggui [7115 1350 0964],
Xing Yirong [6717 4135 2837], Sun Dianzhao [1327 3013 3564], and Shen
Guangdi [3088 0342 0966]]

[Text] I. Introduction

The formation of Schottky junction by Al-GaAs (100) contact plays an important role in such devices as microwave frequency mixers, field effect tubes, CCD's and in large scale GaAs integrated circuits. In the manufacturing of Schottky junctions, the semi-conductor is generally contaminated due to exposure to the atmosphere. We use the technique of molecular beam epitaxy (MBE) to grow GaAs epitaxy under ultra-high vacuum conditions, and achieved ideal Schottky contact at the epitaxial Al monocrystal layers, thus removing oxygen and other impurities.

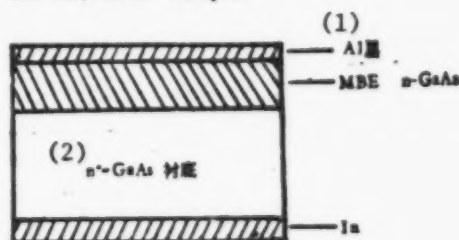
In addition to using electrical technique to measure the properties of Al/GaAs(100) Schottky junction, we also apply surface analysis (AES and XPS) and Raman spectral techniques to study the interface structure. This technique provides a better understanding of the electrical properties of the equipment as well as the relationship between interface reaction and its structure; for this reason, it is a useful tool for designing and manufacturing semi-conductor components. Interface reaction has always been a topic of considerable interest; it has been observed that AlAs layer is formed at the interface by depositing Al on the GaAs(110) surface. [1,2,3] We have also observed AlAs compound at the interface of As-rich GaAs(100), and discovered the formation of solid solution $\text{Al}_{1-x}\text{Ga}_x\text{As}$ as a result of the exchange of Al and Ga atoms in the GaAs epitaxy. In addition, the heat treatment process will affect the electrical properties of the Schottky junction, and promote the interdiffusion of interface elements and the interface reaction; consequently, the Schottky barrier height will increase with increasing annealing temperature.

II. Experiment

A molecular beam epitaxy device, developed jointly by this laboratory and the Shenyang Scientific Instrument Factory, is used to grow Al/GaAs(100)

test samples, whose structure is shown in Figure 1. It has a substrate made of n^+ -GaAs(100) mixed with Te, and uses pure As(6N), pure Ga(6N), and pure Al(6N) as substances for the molecular beam. Prior to epitaxial growth, the substrate is first polished using a chemical-mechanical process and flushed with organic solution and de-ionized water, then it is subject to chemical corrosion using a solution of $H_2SO_4 : H_2O_2 : H_2O = 7:1:1$. After being flushed with de-ionized water and blow-dried, the substrate is immediately bonded to a Mo block with In, and placed in an ultra-high vacuum growth chamber. When heated to a temperature of $580^\circ C$ under a specified As steam pressure, a clean growth surface is obtained by removing the oxidized layer and other impurities attached to the surface; at the same time, In and the n^+ -GaAs substrate combine to form a good Ohm junction. In order to obtain an ideal Al-GaAs structure, we first produce a Si-mixed, n type GaAs layer approximately 1 micron thick; the growth conditions are as follows: the substrate temperature is $580^\circ C - 680^\circ C$; the ratio of As/Ga flow rates is 5-10; and the growth rate is 1 micron/hour. The RHEED observation of the epitaxial surface shows that it has an As-rich, GaAs(100)-C(2x8) structure. The carrier concentration of the MBE using the Hall effect technique is $5 \times 10^{15} cm^{-3}$. One hour after GaAs epitaxy is completed, the substrate is cooled to $\sim 50^\circ C$; and with the As steam pressure reduced to less than 1×10^{-8} torr, a MBE Al film is formed on the GaAs(100) surface. Its growth rate is 40 Å/min, and the thickness of the Al film is 1200 Å; the RHEED observation of the Al film shows that it has a single crystal structure. The annealing process of the test sample is carried out in a vacuum chamber at temperatures of $350^\circ C$ and $450^\circ C$ for a period of 30 minutes.

Figure 1. Structure of an Al/GaAs Sample



Key: 1. Al layer 2. n^+ -GaAs substrate

After being removed from the MBE growth chamber, the Al/GaAs slice is divided into two halves. One half of the slice is placed in a PHI-550 electronic spectrometer vacuum chamber, the other half is subject to a photoetching process to produce two circular Al-film Schottky diodes with diameters of 500 μm and 700 μm respectively.

A systematic study of the electrical properties of Schottky junctions has been carried out using I-V and C-V measurement systems. The electric current of I-V is measured by a MI94- μA ammeter and a TR-B4M oscillatory electrometer, whose measurement accuracy is ± 1 percent. In C-V measurements, a Boonton 76A capacity meter is used to measure the junction capacitance;

its measurement accuracy is better than 10^{-5} pF. The optical measurement of the test sample is made using a T800 laser Raman Spectrometer. It uses a near- 180° back-scattering arrangement, and the light source is a 4880 Å Ar-ion laser. AES and XPS measurements are carried out using a PHI-550 electronic spectrometer under 2×10^{-9} -torr high-vacuum conditions. In making AES measurements, the energy level of the incident electron beam is 5 keV, and the beam current is 3 μ A. The sputtering voltage of the Ar⁺ ions is 2 kV, and the beam current is 1.35 μ A. MgK α X-ray is used as the excitation light source for XPS; the passing energy level is 50 eV, and the number of integrated signals is 30-50. Pure gold samples are also tested using the 4f_{7/2} peak as the standard peak.

III. Results and Discussion

1. Variation of the Electrical Properties of Schottky Junction With Annealing Temperature

Electrical measurements have been taken on both the unannealed MBE Schottky junctions and junctions which are annealed in vacuum under 350°C and 450°C. In C-V measurements, the Schottky barrier height is determined through the differential capacitance in the depletion layer as a function of the externally applied inverse voltage; in I-V measurements, the barrier height is determined using theoretical formulas for thermal electron emissions; the results are presented in Table 1. Both measurement techniques show that the interface Schottky barrier increases after heat treatment. These results are in agreement with the results of Johnson et al.^[4] and those of Thorwald et al.^[5] For unannealed Schottky junctions and junctions annealed at 350°C, the C^{-2} varies linearly with V, with an ideal factor of 1.05. When the annealing temperature reaches or exceeds 450°C, the C-V and I-V characteristics begin to deteriorate, and both the inverse leakage current and the ideal factor increases.

Table 1

(1) 热处理温度		(2) 室温	350°C	450°C
(3) 势垒高度 (eV)	C-V	0.78	0.90	1.1
	I-V	0.62	0.68	0.73

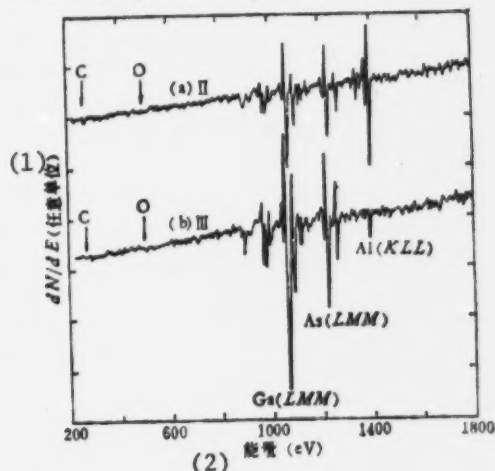
Key: 1. Annealing temperature
2. Room temperature
3. Barrier height (eV)

2. Distribution of Interface Constituents and the Interdiffusion Caused by Heat Treatment

The constituents of the MBE Al/GaAs structure under different heat treatment conditions are measured using an Auger electronic spectrometer. Figure 2 shows the AES at the interface. The arrows in the figure point

out the absence of O and C peaks, i.e., the absence of O and C elements. This illustrates that the Schottky junction produced by MBE technique is an ideal junction which contains no impurities. On the other hand, the Schottky junction produced by conventional techniques contains oxygen and other impurities because the semiconductor surface is exposed to air and therefore subject to oxidization and contamination. [4]

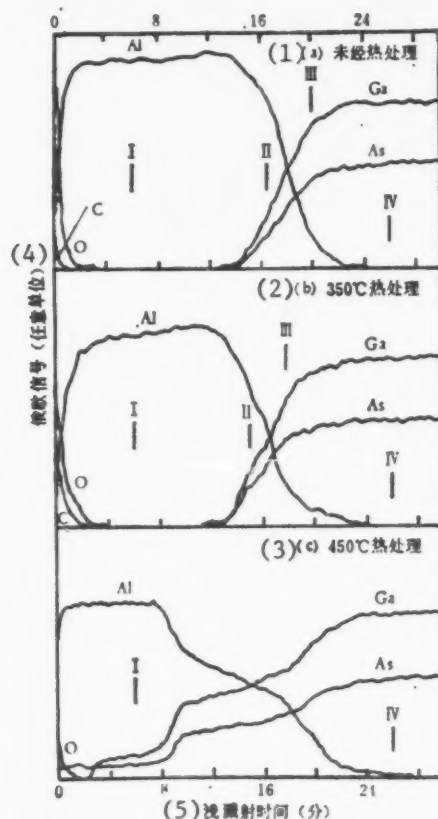
Figure 2. AES at the Interface of MBE Al/GaAs(100). The spectra (a) and (b) are measured near the interfaces of the Al film (II) and the GaAs epitaxial layer (III) respectively.



Key: 1. Arbitrary unit
2. Energy level

Figure 3 shows the depth distributions of the sample constituents under different annealing temperatures. By using an α step tracing instrument, the sputtering rates of the Ar^+ ions are determined to be $\sim 60 \text{ \AA/min}$ relative to the Al film and $\sim 30 \text{ \AA/min}$ relative to the GaAs epitaxy. We can see from Figure 3 that the interface element distributions for unannealed samples are very steep (Figure 3(a)). Samples which are annealed at 350°C show no apparent element interdiffusion effect; the element distribution at the interface is still very steep, but the transition region at the interface extends $30\text{--}60 \text{ \AA}$ in the direction of the Al layer (Figure 3(b)). The I-V characteristics of the Schottky diodes made from the same slice are still very good. However, for samples which are annealed at 450°C , the Ga and As elements almost diffuse through the entire Al layer, and the Al element diffuses into the surface layer of the epitaxial GaAs (Figure 3(c)). The apparent interdiffusion of Al and GaAs destroys the ideal step junction, thus causing deterioration of the electrical properties of the Schottky junction. Therefore, in the manufacturing process of Al/GaAs(100) Schottky junction using molecular beam epitaxy technique, we must ensure that the slices are not subject to temperature higher than 450°C .

Figure 3. Depth Distribution of the Constituents of Al/GaAs Structure Under Different Annealing Temperatures



Key: 1. (a) Unannealed
2. (b) Annealed at 350°C
3. (c) Annealed at 450°C
4. Auger signal (arbitrary unit)
5. Sputtering time (minutes)

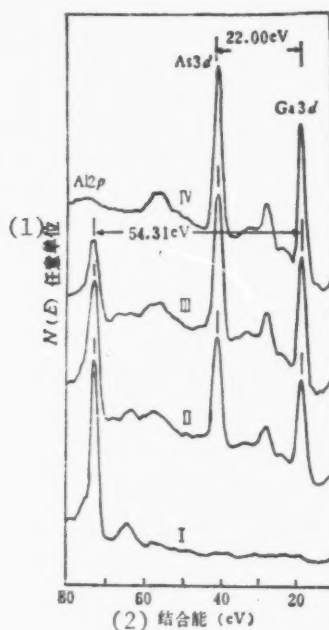
3. Interface Reaction

The interface chemical reaction of metal GaAs is important for the stability and reliability of its Schottky junction. Metals such as Al, Au and Cr can also react chemically with the semiconductor GaAs, and cause it to have the tendency to decompose.^[1] The XPS used in chemical analysis can provide useful information on the chemical bond. For this reason, we perform XPS measurements of the I-IV cross-sections of test samples annealed at different temperatures; for example, the test results of samples annealed at 350°C are shown in Figure 4. The difference in binding energies between the As3d and Ga3d peaks in the interface region (II and III in Figure 4) is measured to be 22.00 eV, which is the same as that in the GaAs epitaxial layer (IV); this illustrates that there is

no chemical displacement in the As3d and Ga3d core energy levels. Also, the difference in binding energies ΔE_b between the Al2p and Ga3d core energy levels is measured to be 54.31 eV. This result is in close agreement with the result of Waldrop et al [6] where ΔE_b is measured to 54.25 eV from XPS spectra in the study of MBE AlAs-GaAs heterojunctions.

Figure 4. Core Energy Spectra of MBE Al/GaAs(100) Structure.

The cross-section locations of spectrum I through spectrum IV are shown in Figure 3. Spectrum I is measured within the Al film; spectrum II and spectrum III correspond to the interface regions near the Al film and the GaAs respectively; spectrum IV is within the GaAs layer.



Key: 1. Arbitrary unit

2. Binding energy

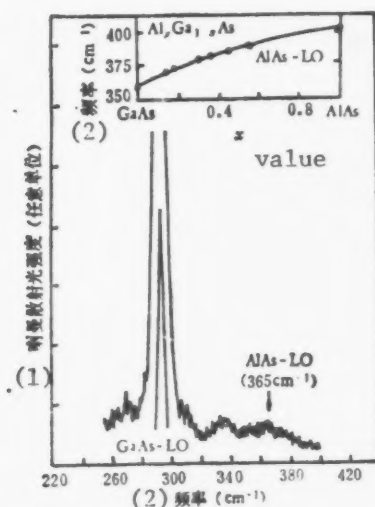
This illustrates that AlAs compounds are present at the MBE Al/GaAs(100) interface. The formation of AlAs and the displacement of the Al2p peak due to interface chemical reaction are also confirmed. In the core energy spectra containing both Al2p peaks and standard Au4f_{7/2} peaks (scan range is 65-85 eV), we have measured a 0.6 eV displacement_r of the Al2p peak toward higher binding energy level. The movement of the Al2p peaks can also be seen from Figure 4; it is in agreement with the results reported by Kahn et al [3] in a study of the Al and GaAs(110) interface. Because As has a higher negative charge (2.0) than Al(1.5), during the chemical reaction in which formation of Al-As bond takes place, the Al atoms will undergo charge transfer, resulting in increased binding energy at the core energy level. There are two types of chemical reactions which form AlAs compounds at the Al-GaAs(100) interface: one is the direct combination of Al atoms with the rich As atoms on the MBE GaAs(100)-C(2/8) surface:



the other is the displacement reaction between Al and GaAs:



It is generally believed that in the GaAs layer, Ga is displaced by Al to form AlAs^[2,4]; however, this can occur only if the Al atoms displace all 4 Ga atoms surrounding As, just like the displacement reaction in the interface region. In fact, the Al atoms which enter the GaAs layer only partially replace Ga to form the solid solution $\text{Al}_x\text{Ga}_{1-x}\text{As}$. To confirm this point, measurements are performed using Raman scattering spectral techniques. The measured results have demonstrated that the optical technique is an effective way to identify the type of Al-Ga displacement reaction which would be difficult to identify by XPS measurements. The MBE Al/GaAs slice is treated with a chemical corrosion process to remove the top layer of Al film; what remains after Al removal is used as the sample for optical measurement. The Raman spectrum obtained by shooting a laser beam into the test sample is shown in Figure 5. The 292 cm^{-1} main peak of the spectrum corresponds to the generic GaAs-LO mode, and the 365 cm^{-1} weak peak corresponds to the generic AlAs-LO mode. But the nature of the small peak in the vicinity of the main peak (at a frequency of approximately 330 cm^{-1}) is still not clear. In a study of the modal frequency of the long-wave-length optical phonon of the solid solution $\text{Al}_x\text{Ga}_{1-x}\text{As}$, Kim et al.^[7] discovered that the modal frequency increases with the value of x . For example, when x increases to 1 (i.e., AlAs compound), the modal frequency of the generic AlAs-LO is approximately 400 cm^{-1} , as shown in the top insert of Figure 5 (the solid curve and the circles are respectively the theoretical curve and the experimental points given by Kim et al). It can be seen from Figure 5 that the generic AlAs-LO peak is located at the frequency 365 cm^{-1} , and no peak exists at the frequency 400 cm^{-1} . This illustrates that the Al-Ga displacement reaction only forms the solid solution $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($x < 1$); it does not produce any AlAs compound ($x=1$). The diffusion coefficient of Al in GaAs is very small; even at a high annealing temperature of 450°C , only a small amount of Al atoms would enter into the GaAs surface layer. From the depth distribution of sample constituents indicated in Figure 3(c), one can roughly estimate the GaAs surface layer to be approximately $200\text{ \AA}$ in thickness.



Key: 1. Raman scattered light intensity
2. Frequency

IV. Conclusion

From the results of electrical and optical measurements and from surface analysis, the following conclusions can be drawn:

1. An ideal Schottky junction with no oxides or other impurities can be obtained using molecular beam epitaxy techniques.
2. When the annealing temperature exceeds 450°C, element interdiffusion occurs at the interface between the metal and the semiconductor; Ga and As almost diffuse into the entire Al layer, thereby causing deterioration of the electrical properties of the Schottky junction. Therefore, elevated temperature should be avoided in manufacturing Schottky diodes.
3. By depositing Al on the MBE As-rich GaAs(100)-C(2x8) surface, interface reaction will take place and AlAs compounds will form in the interface region. Heat treatment will promote interface reaction and increase the Schottky barrier height.
4. The Al atoms which diffuse into GaAs will partially displace Ga to form $\text{Al}_x\text{Ga}_{1-x}\text{As}$ solid solution.

Thanks are due to Comrade Wang Zhaoping and Comrade Han Hexiang for their assistance in making Raman spectral measurements during this experiment.

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CSO: 4008/1060

PHYSICAL SCIENCES

TWO-DIMENSIONAL ELECTRON GAS IN MBE GROWN SELECTIVELY DOPED GaAs/N-AlGaAs
HETEROSTRUCTURES

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 2, Mar 86 pp 216-218

[Article by Jiang Pihuan [3068 0012 2719], Li Yuexia [2621 2588 7209], Yang Fuhua [2799 1381 5478], and Wang Xinghua [3769 2622 5478], Institute of Semiconductors, Chinese Academy of Sciences: "Two-Dimensional Electron Gas in MBE Grown Selectively Doped GaAs/N-AlGaAs Heterostructures," received 20 March 1985]

[Text] English Abstract: Transport properties of two-dimensional electron gas in MBE grown selectively doped GaAs/N-AlGaAs heterostructures have been measured in strong magnetic field at low temperature. SdH oscillation and quantized Hall effect have been observed.

Our institute's MBE group manufactured a selectively doped GaAs/N-AlGaAs heterostructure whose structure is as follows: First we grew epitaxially a 1 μm thick non-doped GaAs layer on a Cr semi-insulated (100) GaAs substrate, then an isolation layer of non-doped $\text{Al}_x\text{Ga}_{1-x}\text{As}$ about 60 $\text{\AA}$ thick was grown, on top of which was an Si mixed N- $\text{Al}_x\text{Ga}_{1-x}\text{As}$ layer 1000 $\text{\AA}$ thick with a dopant concentration of approximately $1.0 \times 10^{18} \text{ cm}^{-3}$, and finally on the surface was built a 200 $\text{\AA}$ non-doped GaAs layer. The AlAs gram molecular number x was about 0.3. The electrons produced by the donor impurity Si in the $\text{Al}_x\text{Ga}_{1-x}\text{As}$ transferred to the GaAs side of the boundary surface, and formed two-dimension electron gas in the vicinity of the boundary.

For measuring, we used the alloy method to manufacture an indium electrode, with the electrode distribution being Van der Pauw's equation. We made the boundary surface of the heterostructure perpendicular to the magnetic field and at low temperature measured the relationship of the specific resistance tensors ρ_{xx} and ρ_{xy} with changes in the magnetic field intensity B . See Figure 1 for typical results.

In a weak magnetic field, ρ_{xy} and B are in direct proportion, their ratio being Hall's coefficient R , and using the classical equation

$$R = \frac{1}{Nec} \quad (1)$$

we can compute the electron concentration.

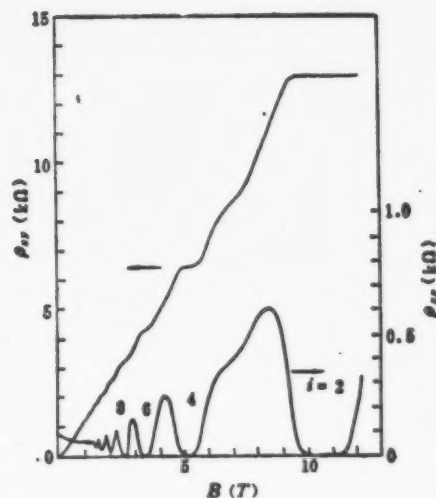


Figure 1. Relationship of ρ_{xx} and ρ_{xy} with changes in the magnetic field intensity B . No 84147, $T = 2.5K$, ρ_{xx} : $I = 50 \mu A$, ρ_{xy} : $I = 10 \mu A$

In a stronger magnetic field, we observed that the extremely small values of the quantized Hall effect (ρ_{xy}), ρ_{xx} and the SdH oscillation (ρ_{xx}) was in platform correspondence with ρ_{xy} . In the $n = 1$ Landau energy level we observed spin-spin splitting. When the electrons have just filled the Landau energy level of quantum number n , the concentration is

$$N = 2(n+1) \frac{eB}{hc} = i \frac{eB}{hc}, \quad (2)$$

in which eB/hc is the degeneracy of the Landau energy level, the integer $i = 2(n+1)$ expresses the Landau energy level filled with electrons. From equation (2) we can tell that the following equation is suitable for making ρ_{xx} appear the extremely small magnetic field intensity B_{min}

$$(B_{min})^{-1} = \frac{ie}{hc} / N. \quad (3)$$

The relationship of the integer and the $(B_{min})^{-1}$ obtained from experiments was drawn as a curve (Figure 2) in which the dots form a straight line. From this we can tell that they conform to equations (2) and (3), and we can identify the corresponding i value of the smallest value of ρ_{xx} . From the slope of the straight line we can find the electron concentration N .

Table 1 gives the relevant data of the two samples: μ is the electron mobility, N_R is the electron concentration calculated from the Hall coefficient in a low magnetic field, N_{SdH} is the electron concentration calculated from the SdH oscillation. The electron concentrations obtained using the two methods are close, which indicates that conductance is produced from two-dimensional electron gas, and that the allied conductance can be ignored.

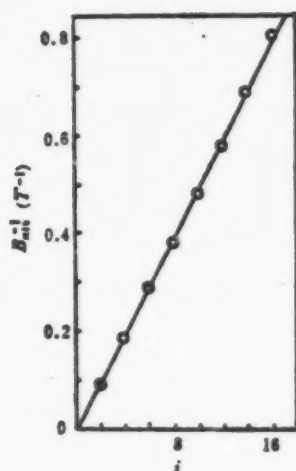


Figure 2. Relationship of B_{min} and the integer. No 84147

Table 1

Sample	Temperature	μ ($m^2/V \cdot s$)	N_R (cm^{-2})	N_{SdH} (cm^{-2})
84012	4.2	19	3.7×10^{11}	4.0×10^{11}
84147	2.5	14	5.0×10^{11}	5.0×10^{11}

When the relationship of ρ_{xy} with changes in B becomes a platform, the error of its deflection of the quantum Hall resistance theoretical value h/e^2 is of a magnitude of 10^{-3} . Figure 3 is the curve of the ρ_{xy} of samples of two different electron concentrations. From the figure it can be seen that the difference in electron concentration only changes numerical value of the magnetic field intensity B when the platform appears.

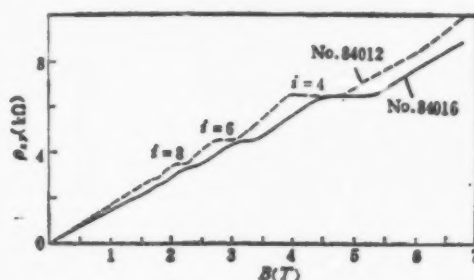


Figure 3. Relationship of ρ_{xy} of two samples of different electron concentrations with changes in B .

Sample No 84012 $N = 3.7 \times 10^{11} cm^{-2}$

Sample No 84016 $N = 4.1 \times 10^{11} cm^{-2}$

$T = 4.2K$, $I = 50 \mu A$

The authors thank Cai Hong [5591 3126] and Dong Mouqun [5516 6180 5028] for their help in the experiments.

REFERENCES

1. Chen Zonggui [7115 1350 0964], Liang Jiben [2733 1015 2609], Sun Dianzhao [1327 3013 3564], Huang Yunheng [7806 6663 5899], and Kong Meiyong [1313 2734 1758], BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] 5, 694 (1984).

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PHYSICAL SCIENCES

EFFECT OF WATER COMPRESSIBILITY ON OCEANIC INTERNAL WAVE STUDIED

Qingdao SHANDONG HAIYANG XUEYUAN XUEBAO [JOURNAL OF SHANDONG COLLEGE OF OCEANOLOGY] in Chinese Vol 14 No 3, 15 Sep 84 pp 13-18

[Article by Fang Xinhua [2455 2946 5478] and Wang Jingming [3760 2529 2404], Department of Physical Oceanography and Marine Meteorology, Shandong College of Oceanography; paper received 31 August 1983]

[Text] 1. Description of the Problem

To calculate the Brunt-Vaisala frequency N , the following equation should be used when compressibility is taken into account:

$$N^2 = - \left(\frac{g}{\bar{\rho}} \frac{d\bar{\rho}}{dz} + \frac{g^2}{c_s^2} \right) \quad (1)$$

where $\bar{\rho} = \bar{\rho}(z)$ is the density distribution at resting state,
 c_s is sound velocity in sea water, about 1500 m/sec,
 g is the acceleration due to gravity,
 z axis is vertical and pointing upward.

The term g^2/c_s^2 in equation (1) represents the effect of compressibility on density and its magnitude is 10^{-4} sec^{-2} . From a sharp thermocline to deep down under the ocean, $O(N^2)$ should be between 10^{-4} and 10^{-8} sec^{-2} . It is obvious that even at a thermocline, the second term cannot be overlooked. Table 1 is from Knauss (1978) and the following relationship exists between stability E and the Brunt-Vaisala frequency N :

$$N^2 = Eg$$

From the table, it can be seen that when the depth reaches 200 meters, $O(N^2) = O(g^2/c_s^2)$. Therefore, the density change due to compressibility cannot be ignored.

Many prominent investigators of internal wave use the incompressible model in their discussions of internal wave theory, that is the condition of incompressibility ($\nabla \cdot \mathbf{V} = 0$) is present in their complete sets of fluid dynamic equations. Furthermore, a majority of them, e.g., Garrett and Munk (1972,

1975), Desaubies (1973), LeBlond and Mysak (1978), Turner (1979), and Phillips (1977), overlooked the north component of earth's rotation (i.e., the "classical approximation" was used). In dealing with internal wave problems, equation (1), which is a differential equation of internal wave derived under the assumption of incompressibility, is often used to address the effect of compressibility on N . So there lies a logical lapse. Some efforts of the authors to solve this problem is presented in this article. Attempts were made to examine the effect of compressibility through order of magnitude comparison, using the constant entropy assumption and the equations for vortexing, compressible fluid. Also the deep sea internal wave equations, applicable where N is small, were derived.

Table 1. The Distribution of Temperature, Salinity, and Stability With Depth (d , S , T , and E denote depth, salinity, temperature, and stability, respectively)

d (m)	S (‰)	T (°C)	E (10^{-8}m^{-1})	d (m)	S (‰)	T (°C)	E (10^{-8}m^{-1})
50	34.992	27.06	2500	1000	34.524	4.14	63
100	35.079	23.83	1800	1500	34.502	2.78	35
150	35.071	21.14	1400	2000	34.638	2.07	20
200	34.834	18.10	1200	3000	34.674	1.61	11
300	34.186	10.81	730	4000	34.688	1.48	1
500	34.271	6.54	230	5000	37.700	1.45	2
700	34.454	5.47	110				

2. Analysis of the Equations

Following the conventional coordinates system, x_1 , x_2 , and z point east, north and up, respectively, and the origin is at the sea surface in equilibrium. There exist the vertical component f_1 and north component f_2 of earth's rotation:

$$f_1 = 2\Omega \sin\varphi,$$

$$f_2 = 2\Omega \cos\varphi,$$

where Ω is the angular velocity of earth's rotation and φ is the latitude. Let's assume that

$$O(f_1) = O(f_2) = O(2\Omega),$$

i.e. exclude the equator and polar regions. Also assume that sea water is an ideal, compressible fluid and its motion is entropy-conserved, then the linear equations of motion for pulse momentum are:

$$\begin{aligned}
\frac{\partial u_1}{\partial t} - f_1 u_2 + f_2 u_3 + \frac{1}{\rho} \frac{\partial p}{\partial x_1} &= 0 \\
\frac{\partial u_2}{\partial t} + f_1 u_1 + \frac{1}{\rho} \frac{\partial p}{\partial x_2} &= 0 \\
\frac{\partial u_3}{\partial t} - f_2 u_1 + \frac{\rho}{\rho} g + \frac{1}{\rho} \frac{\partial p}{\partial z} &= 0 \\
\frac{\partial \rho}{\partial t} + u_3 \frac{\partial \rho}{\partial z} + \bar{\rho} \left(\frac{\partial u_1}{\partial x_1} + \frac{\partial u_2}{\partial x_2} + \frac{\partial u_3}{\partial z} \right) &= 0 \\
\frac{\partial \rho}{\partial t} = \frac{1}{c^2} \frac{\partial p}{\partial t}
\end{aligned} \tag{2}$$

The physical meanings of all notations used in the equations are the same as the conventional usages in the majority of internal wave literature and no further explanation is necessary.

Let each pulse momentum have a solution in the following form:

$$\begin{aligned}
\{u_1, u_2, u_3, p, \rho\} = \\
= \{U_1(z), U_2(z), U_3(z), \Pi(z), P(z)\} \cdot \exp[i(k_1 x_1 + k_2 x_2 - \omega t)]
\end{aligned} \tag{3}$$

Substituting (2) with (3) and cancelling out U_1 , U_2 , Π and P after proper manipulations, an equation for $U_3(z)$ is obtained:

$$\begin{aligned}
U_3' - \left[\frac{i 2 f_1 f_2 k_2}{\omega^2 - f_1^2} + \frac{N^2}{g} + \frac{g}{c^2} \right] U_3 + \frac{1}{(\omega^2 - f_1^2)^2} \left[f_1^2 k_1^2 + (k_1^2 + k_2^2)(N^2 - \omega^2) - \right. \\
\left. - \omega f_2 k_1 \left(\frac{N^2}{g} - \frac{g}{c^2} \right) + \omega^2 (\omega^2 - f_1^2 - f_2^2) \frac{1}{c^2} + i f_1 f_2 k_2 \left(\frac{N^2}{g} + \frac{g}{c^2} \right) \right] U_3 = 0
\end{aligned} \tag{4}$$

In order to eliminate those terms containing U_3' , let

$$U_3 = W(z) \Phi(z) \tag{5}$$

where

$$\Phi(z) = \exp \left[\frac{1}{2} \int \left(\frac{N^2}{g} + \frac{g}{c^2} + i \frac{2 f_1 f_2 k_2}{\omega^2 - f_1^2} \right) dz \right] \tag{6}$$

Thus, an equation for $W(z)$ is obtained:

$$W'' + m^2 W = 0 \tag{7}$$

in which

$$\begin{aligned}
m^2 = & \left[k^2 \frac{N^2 - \omega^2}{\omega^2 - f_1^2} + \frac{\omega^2 f_1^2 k_1^2}{(\omega^2 - f_1^2)^2} \right] + \left(\frac{N'}{N} - \frac{\omega f_2 k_1}{\omega^2 - f_1^2} - \frac{N^2}{4g} \right) \frac{N^2}{g} + \\
& + \left[\frac{\omega^2 (\omega^2 - f_1^2 - f_2^2)}{\omega^2 - f_1^2} + \frac{\omega f_2 k_1 g}{\omega^2 - f_1^2} - \frac{N^2}{2} \right] \frac{1}{c^2} - \frac{1}{c^4} \frac{g^2}{4}
\end{aligned} \tag{8}$$

where $k = \sqrt{k_1^2 + k_2^2}$, is the horizontal wave number.

If the boundary conditions of a flat sea floor and a rigid, flat sea surface are adopted, then

$$m = \frac{j\pi}{d}$$

where d is the depth and j the indice of modeled state.

Take $O(d) = 10^3$ m,

then for the lowest state internal wave with maximum energy

$$O(m^2) = 10^{-6} \text{ m}^{-2}$$

Since $O(f_1) = O(f_2) = O(2\Omega) = 10^{-4} \text{ sec}^{-1}$

and let's further take

$$\begin{aligned} O(N) &= 10^{-3} \text{ sec}^{-1}, \\ O(\omega) &= O(N), \end{aligned}$$

and assume $O\left(k^2 \frac{N^2 - \omega^2}{\omega^2 - f_1^2}\right) = O(m^2) = 10^{-6} \text{ m}^{-2}$,

then $O(k^2) = 10^{-6} \text{ m}^{-2}$,

assume also that $O(k_1^2) = O(k_2^2) = O(k^2) = 10^{-6} \text{ m}^{-2}$,

then the order of magnitude of each term in m^2 are as follows (dimension: m^{-2}):

$$\begin{aligned} m^2 &= \left[k^2 \frac{N^2 - \omega^2}{\omega^2 - f_1^2} + \frac{\omega^2 f_1^2 k_1^2}{(\omega^2 - f_1^2)^2} \right] + \left(\frac{N'}{N} - \frac{\omega f_2 k_1}{\omega^2 - f_1^2} - \frac{N^2}{g} \right) \frac{N^2}{g} + \\ 10^{-6} &\approx [10^{-6} + 10^{-8}] + \left(\frac{N'}{N} - 10^{-4} - 10^{-7} \right) 10^{-7} + \\ &+ \left[\frac{\omega^2 (\omega^2 - f_1^2 - f_2^2)}{\omega^2 - f_1^2} + \frac{\omega f_2 k_1 g}{\omega^2 - f_1^2} - \frac{N^2}{2} \right] \frac{1}{c^2} - \frac{1}{c^4} \frac{g^2}{4} \\ &+ [10^{-6} + 10^{-3} - 10^{-6}] 10^{-6} - 10^{-10} \end{aligned}$$

Ignore the small, higher order quantities, then

$$m^2 = k^2 \frac{N^2 - \omega^2}{\omega^2 - f_1^2} + \frac{NN'}{g} \quad (9)$$

If $O(N') < 10^{-2} \text{ sec}^{-1} \text{m}^{-1}$ (which is closer to reality in ocean), then the second term in above equation can be omitted and (9) regresses into an expression often seen for vertical wave number

$$m^2 = k^2 \frac{N^2 - \omega^2}{\omega^2 - f_1^2} \quad (10)$$

(8) and (9) are still valid when $O(\omega) = O(f)$.

In deep water often $O(N) = O(f_1) = O(f_2) = 10^{-4} \text{ sec}^{-1}$. If taking $O(N') = O(N/d) = 10^{-7} \text{ m}^{-1} \text{sec}^{-1}$ (which is an overestimation for deep locations where N are small) and using the above-mentioned order of magnitude comparison method, then, for m^2 , only the terms within the first brackets in (8) are in the order of 10^{-6} m^{-2} while all others are smaller. Therefore, (8) regresses into

$$m^2 = k^2 \frac{N^2 - \omega^2}{\omega^2 - f_1^2} + \frac{\omega^2 f_1^2 k_1^2}{(\omega^2 - f_1^2)^2} \quad (11)$$

And (7) is greatly simplified:

$$W'' + \left[k^2 \frac{N^2 - \omega^2}{\omega^2 - f_1^2} + \frac{\omega^2 f_1^2 k_1^2}{(\omega^2 - f_1^2)^2} \right] \bar{W} = 0 \quad (12)$$

Now we go back to check the order of magnitude for $\hat{\phi}(z)$, it can be easily seen that the order of magnitude of the first two terms within the integral in (6) are smaller than the third term, so

$$\hat{\phi}(z) = \exp \left[i \frac{f_1 f_2 k_2}{\omega^2 - f_1^2} z \right] \quad (13)$$

and

$$U_1(z) = W(z) \exp \left[i \frac{f_1 f_2 k_2}{\omega^2 - f_1^2} z \right] \quad (14)$$

3. Discussions

In the fluid dynamic problems dealing with homogeneous density fluid, the effect of compressibility on the flow is expressed by the Mach number M (the ratio of fluid flow velocity to the sound velocity at the same location). With larger M 's, the terms containing M cannot be ignored when compared with other terms in the equation and the problem should be treated as compressible. On the other hand, when M is small, those terms containing M can be omitted and the motion of fluid can be treated as incompressible. Because the velocity of sea water motion caused by oceanic internal waves is far smaller than the sound velocity in water, the oceanic internal wave motion has to be incompressible according to the principle described above. However, except for shallow upper ocean layers, the effect of compressibility has to be considered in actual oceanic internal waves and is represented by the influence of compressibility on N . N is a physical property of a lamellar fluid in

equilibrium rather than a kinetic quantity and is independent of the velocity of fluid motion. Therefore, the effect of compressibility on it naturally cannot be judged by the magnitude of M . The significance of the effect of compressibility is determined by the extent temperature, salinity and other physical properties affect the density. At the sharp thermoclines of upper ocean layer, changes of temperature and salinity with depth are greater and they are probably important contributing factors to the density change with depth. In deep water, the changes of temperature and salinity with depth are small and the density change with depth is also small (as can be seen from Table 1). The small change of density is mainly due to compressibility.

Because the differential equations of internal wave motion have the same form under both compressible and incompressible conditions, the only difference between them lies in the expression for N . Therefore, in dealing with actual oceanic internal waves, correct results are obtained when one uses the internal wave equations derived under the assumption of incompressibility and the N 's in these equations are substituted with the measured values which are influenced by compressibility, although it is logically inconsistent. Through our efforts as presented in this article this inconsistency is eliminated.

Equations (1), (5) and (11)-(14) are obtained under conditions more consistent with those in deep water (low N value and constant entropy) and, therefore, it is reasonable to believe that they more accurately describe the rules of internal wave motion in deep water. Judged from the perspective of WKB-type approximation, they are no more complex than ordinary equations. In addition, the N values at great depth are nearly constant and that makes the problems easier to handle.

Kamenkovich and Kulakov (1977) have derived equations that correspond to (4) under the assumption of incompressibility (which naturally do not contain terms that reflect the effect of compressibility) and solved those equations along with discussions. Therefore, no solving these equations and detailed discussions are intended in this article. However, several points are worth mentioning: First, the f_2 and k_2 in (11) and (14) appear together. When $k_2 = 0$, i.e. no north component of wave number, even with a small N , f_2 will have no impact on W or U_3 . Secondly, the change in the frequency range of internal wave is no longer $f_1 < \omega < N$ but rather

$$\omega_2 < \omega < \omega_1,$$

where

$$\omega_{1,2}^2 = \frac{1}{2} \left\{ N^2 + f_1^2 + \left(f_2 \frac{k_2}{k} \right)^2 \pm \sqrt{ \left[N^2 + f_1^2 + \left(f_2 \frac{k_2}{k} \right)^2 \right]^2 - 4N^2 f_1^2 } \right\}$$

When $k_2 = 0$ or $f_2 = 0$, it reverts to $\omega_1 = N$ and $\omega_2 = f_1$. Otherwise, they would be associated with the complex factor $(f_2 k_2 / k)$. This is a very significant result. It shows that, when N is very small, the upper and lower limits of internal wave frequency vary with the direction of horizontal propagation of internal wave. The results of LeBlond and Mysak (1978) did not reveal this feature. Thirdly, because U_3 , as expressed in (14), contains

the wave factor $\exp\left[i\frac{f_1 f_2 k_2}{\omega^2 - f_1^2}z\right]$, even if $W(z)$ (which decays exponentially with depth) of the zero state is obtained from (12), $U_3(z)$ would still maintain the feature of waveform changing with depth z .

REFERENCES

1. Desaubies, Y.J.F. (1973), "Internal Waves Near the Turning Point," GEOPHYSICAL FLUID DYNAMICS, 5, 143-154.
2. Garrett, C.J.R. and Munk, W. (1972), "Space-Time Scales of Internal Waves," GEOPHYSICAL FLUID DYNAMICS, 2, 225-264.
3. Garrett, C.J.R. and Munk, W. (1975), "Space-Time Scales of Internal Waves: A Progress Report," J. GEOPHYS. RES. 80, 291-297.
4. Knauss, J.A. (1978), "Introduction to Physical Oceanography." Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
5. LeBlond, P.H. and Mysak, L.A. (1978), "Waves in the Ocean." Elsevier Scientific Publishing Company, Amsterdam-Oxford, New York.
6. Phillips, O.M. (1977), "The Dynamics of the Upper Ocean," Cambridge Univ. Press, 2nd ed.
7. Turner, J.S. (1979), "Buoyancy Effects in Fluids," Cambridge Univ. Press, 2nd ed.
8. Каменковч, В. М. И Кулаков, А. В. (1977) К вопросу влияния вращения на волны в стратифицированном океане. Океанология Вып. 3, Т. XV, 400-410.

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PHYSICAL SCIENCES

WIND WAVES IN GULF OF BOHAI STUDIED

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"A Study of Wind Waves in the Gulf of Bohai"*]

[Text] Abstract: The wind wave generated during the passing of a cold wave is one of the most dangerous waves in Bohai. Through the analysis of a continuous record of the wind waves during the passing of a cold wave in early November 1968, it is pointed out in this article that, during the period of strong northerly wind following the passing of a cold wave in winter or spring, the development and decay of the wind wave spectrum in the waters of the Gulf of Bohai are mainly dictated by wind speed. The changes in the shape and scale parameters of the wind wave spectrum are also discussed and their respective formulas given.

The wind wave generated during the passing of a cold wave is one of the most dangerous waves in Bohai. In recent years, many scientists have investigated such problems as the cause and distribution of Bohai's huge waves.^{1,2} However, reports on the cold-wave-associated wind and wave have yet to appear. Based on the wind and wave data gathered during the passing of a cold wave, several aspects of the wind wave caused by the cold wave were studied and the correlation of the wind and wave is described in this article.

I. Features of Cold Wave Passages in the Gulf of Bohai

The passing of a cold wave is a process of the mighty cold air from Asia Minor or northern China invading south or southeast. In the process, strong wind accompanied by a drastic temperature drop occurs over a large area. Because the strength of cold air and the path its center travels vary, the strength of the wind and the extent of temperature drop also vary. By analyzing the

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historical weather information, it is found that, under the influence of a cold wave, winds on the scale of 8-9 can occur and the wind direction generally falls between NW and NE.

The cold wave of early November 1968, studied in this article, is a typical weather process of the type that a cold front is accompanied by a low pressure system. The wind direction over the Gulf of Bohai was between ENE and N with maximum wind speed reaching 18 m/sec.

II. Wave Data

In this article, 20 sets of wind and wave data were collected (see Table 1). They came from the observation data gathered at a site 18 km east of Xingang, Tanggu ($38^{\circ}53'N$, $117^{\circ}51'E$) by a wave meter modified from an ultrasound echo ranging device. The wind elements were recorded with a hand-held wind speedometer at the top of an observation deck in the sea. The criteria for data selections were: (a) The wave was registered for greater than 15-minute period and there were no apparent change in wind direction and wind speed within half an hour before and after the registration; (b) the simultaneous observation data of the wind were present; (c) the calculated wave spectrum had a distinctive main peak and relatively small secondary peaks.

The calculations of wave spectrum were mainly done by correlation method with some by Fast Fourier Transformation (FFT). The scattering data sampling time intervals were 0.75 s for both methods and other parameters were presented in Table 2.

III. Characteristics of the Development of Wind Wave Frequency Spectrum

Figure 1 shows the correlation of wind and wind wave during 5-10 November 1968. The correlation of wave development and decay with fetch, wind direction and wind speed can be seen from the changes with time of wind elements and wind wave spectrum peaks $S(\omega_M)$ as shown in the figure. Because the Gulf of Bohai is a semi-closed bay circled by land on three sides with only east side open to the Bohai and the strong winds generated by cold wave are predominantly northeasterly or northerly, the resulting wind waves are fetch-limited waves. Therefore, fixed wind direction implies fixed fetch and the impact of fetch on wind waves is reflected by the changes of wind direction. It can be seen from Figure 1 that, with steady wind direction, the wind waves are not significantly affected by wind duration. Rather, they change with wind speed.

It is clear from Table 3 that, during the passing of a cold wave, the wind wave spectrum peak frequency (ω_M) varies within the range of 0.8-2.5 rad/s and the corresponding wind wave period T is between 2.5 to 7.8 s. This confirms that the wind waves within the waters of the Gulf of Bohai have a shorter period and higher frequency. The corresponding spectrum peak $[S(\omega_M)]$ can reach a maximum of $0.5896 \text{ m}^2 \cdot \text{s}$.

Table 1. Original Data

(1) (2) 资料 号	(3) 观测日期(日)	(4) 观测时间 (时, 分)	(5) 风 向	(6) 风 速 (m/s)	(7) 风 区 (km)	(8) 水深(m)
1	5	06:36	SW	9.0	35	9.3
2	6	20:46	S	8.5	70	7.5
3	7	10:53	NE	8.5	39	8.4
4	7	11:30	NE	11.0	39	8.7
5	7	12:54	NE	15.0	39	9.8
6	7	14:45	ENE	18.0	78	11.4
7	7	15:45	ENE	16.0	78	11.4
8	7	17:05	ENE	14.0	78	11.2
9	7	18:05	ENE	13.0	78	10.5
10	7	19:05	ENE	12.0	78	9.9
11	7	20:05	ENE	10.0	78	9.3
12	8	07:00	N	12.0	33	10.0
13	8	09:42	N	12.0	33	9.2
14	8	11:35	N	13.0	33	7.8
15	8	12:35	N	11.0	33	8.7
16	8	15:30	NNE	15.0	42	9.8
17	9	08:37	N	16.0	33	8.7
18	9	10:50	N	13.0	33	7.4
19	9	17:13		12.0		8.5
20	10	07:20	NW	8.0	14	8.6

Key:

- | | |
|-------------------------------|-------------------|
| 1. Data | 5. Wind direction |
| 2. Number | 6. Wind speed |
| 3. Observation date (day) | 7. Fetch |
| 4. Observation time (hr, min) | 8. Depth |

Table 2. Parameters for the Calculation of Wave Spectrum

(1) 方 法	(2) 项 目	(3) 资料采样个数	(4) 计算的谱值个数	(5) 自由度	(6) Nyquist 频率(Hz)
(7) 相关法		1600	42	75.69	0.667
FFT method		1024	64	16.00	0.667

Key:

- | | |
|--|-----------------------|
| 1. Method | 5. Degree of freedom |
| 2. Item | 6. Nyquist frequency |
| 3. Number of data samplings | 7. Correlation method |
| 4. Number of calculated spectrum peaks | |

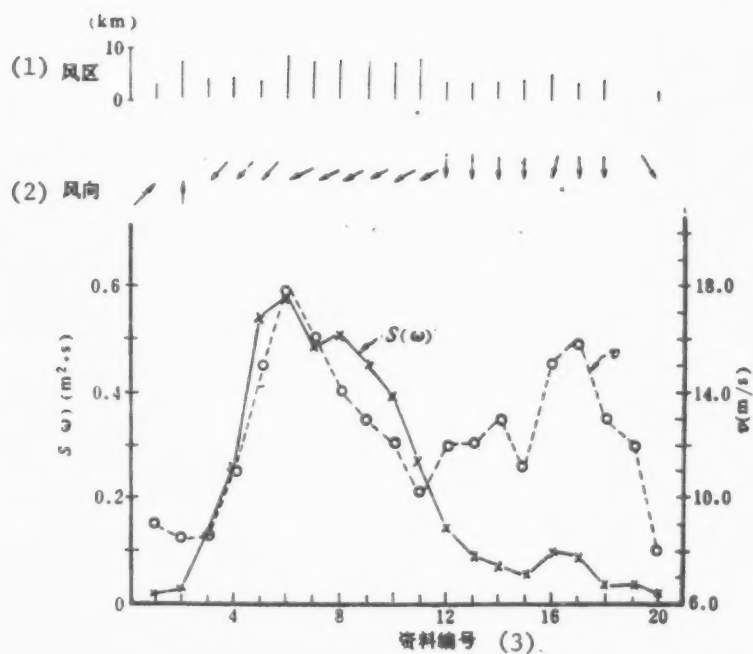


Figure 1. Correlation of Wind and Wind Wave
 ----Wind speed curve
 ——Time-dependence of spectrum peak

Key:

1. Fetch
2. Wind direction
3. Data number

Table 3. Spectral Parameters

(1) 资料编号	(2) 零阶矩 m_0	(3) 谱宽度 σ ν		(4) 谱峰值 ($m^2 \cdot s$) $S(\omega_M)$	(5) 谱峰频率 (弧度/s) ω_M	(6) 无因次谱 峰频率 f_m	(7) 无因次风区 β	(8) 无因次能量 $\bar{E}$
1	0.0308	0.7805		0.0222	1.4	0.2044	4.24×10^3	9.03×10^{-4}
2	0.0252	0.7034		0.0288	1.4	0.1930	9.50×10^3	9.29×10^{-4}
3	0.0927	0.7224	0.1683	0.1257	1.4	0.1930	5.30×10^3	3.42×10^{-3}
4	0.1255	0.6623	0.3945	0.2572	1.4	0.2498	3.16×10^3	1.66×10^{-3}
5	0.2615	0.7319	0.1124	0.5422	1.2	0.2910	1.70×10^3	9.94×10^{-4}
6	0.4912	0.8191	0.7033	0.5869	0.9	0.2628	2.36×10^3	9.01×10^{-4}
7	0.3113	0.7618	0.5105	0.4877	0.9	0.2336	2.99×10^3	9.14×10^{-4}
8	0.4216	0.8523	0.6561	0.5163	0.9	0.2044	3.90×10^3	2.06×10^{-3}
9	0.2579	0.7808		0.4483	0.9	0.1823	4.53×10^3	1.74×10^{-3}
10	0.3038	0.8196	0.6575	0.3906	0.9	0.1752	5.31×10^3	2.82×10^{-3}
11	0.2250	0.7775	0.5228	0.2707	0.8	0.1298	7.65×10^3	4.34×10^{-3}
12	0.1088	0.6651		0.1463	1.4	0.2726	2.25×10^3	1.01×10^{-3}
13	0.0660	0.7486		0.0929	1.4	0.2718	2.25×10^3	6.13×10^{-4}
14	0.0587	0.7095		0.0758	1.6	0.3366	1.92×10^3	3.95×10^{-4}
15	0.1133	0.8240		0.0621	1.2	0.2141	2.68×10^3	1.49×10^{-3}
16	0.0701	0.7218		0.0985	1.5	0.3722	1.83×10^3	2.67×10^{-4}
17	0.0669	0.6959		0.0884	1.4	0.3634	1.23×10^3	1.96×10^{-4}
18	0.0404	0.6716		0.0360	1.5	0.3164	1.86×10^3	2.72×10^{-4}
19	0.0409	0.6577		0.0422	1.5	0.2920		3.80×10^{-4}
20	0.0180	0.6556		0.0113	2.5	0.3245	2.15×10^3	8.46×10^{-4}

Key:

- | | |
|----------------------|------------------------------------|
| 1. Data | 5. Spectrum peak frequency (rad/s) |
| 2. Zero-order moment | 6. Non-dimensional peak frequency |
| 3. Spectrum width | 7. Non-dimensional fetch |
| 4. Spectrum peak | 8. Non-dimensional energy |

Figure 2 is the spectrum density diagram showing the development and decay of wind waves from 10:53 to 19:10, 7 November. It can be seen from the graph that as the wind speed (v) fluctuates, so does the spectrum density [$S(\omega)$]. At 10:53 of 7 November, the wind direction was ENE, $v = 8.5$ m/s and $S(\omega_M) = 0.1257$ $m^2 \cdot s$; at 14:50, v increased to 18 m/s and $S(\omega_M)$ was also increased to 0.5869 $m^2 \cdot s$; and at 20:07, v decreased to 9.3 m/s and $S(\omega_M)$ was decreased to 0.2707 $m^2 \cdot s$ accordingly. Also, the $S(\omega)$ curves 3-6 in Figure 2 indicate the existence of "overshooting" phenomenon in the process of wind wave development. On curve 4, $S(\omega_M) = 0.2573$ $m^2 \cdot s$ and $\omega_M = 0.14$ rad/s. But on curve 5, which is 84 min later than curve 4, $S(\omega_M)$ is only 0.1720 $m^2 \cdot s$ at the spectrum frequency of $\omega = 0.14$ rad/s. This shows that when wind wave is growing with wind speed, the $S(\omega_M)$ noticeably exceeds, at the corresponding frequency, those spectrum peaks observed during the later-stage development of the wind wave.

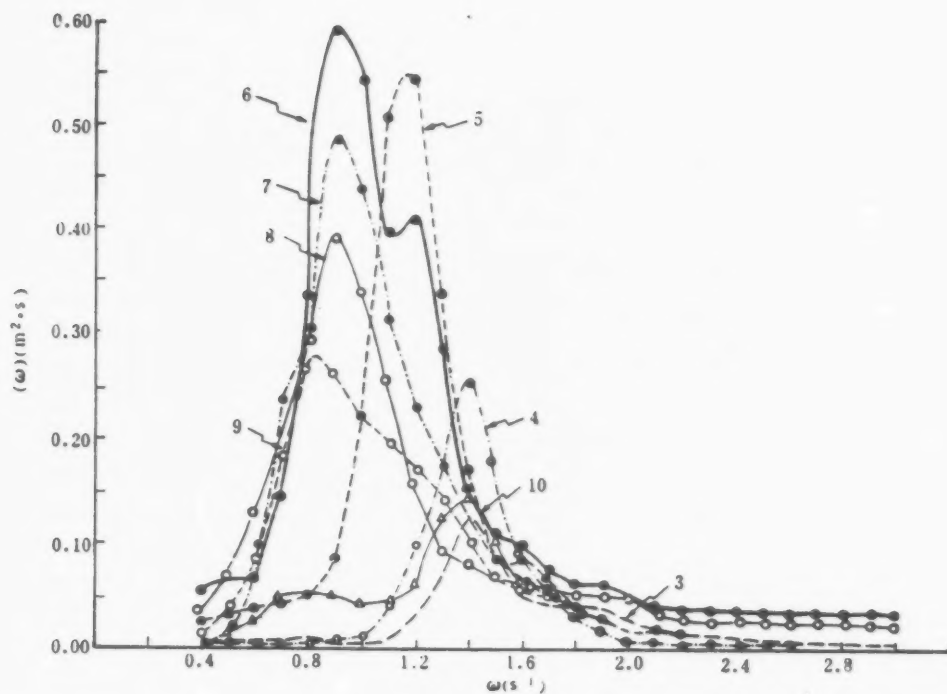


Figure 2. Spectral Density of Wind Waves

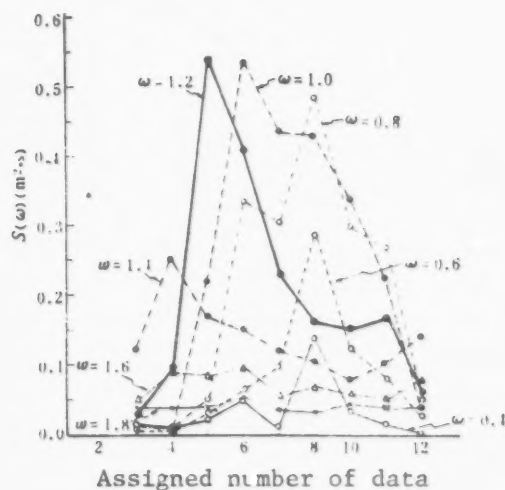


Figure 3. Time Variation of $S(\omega)$

To observe more clearly the change of $S(\omega)$ with time, a graph of $S(\omega)$ versus time was drawn (see Figure 3), using wind wave frequency as a parameter. From the diagram, it can be seen that, when $\omega > 1.5$ rad/s, $S(\omega)$ changes very little

with time. And when $\omega = 1.8$ rad/s, $S(\omega)$ basically remains unchanged. This shows that all component waves reach the equilibrium range of the wave spectrum at the high frequency end.

IV. The Correlation of Wind Wave Spectrum Shape Parameters and the Spectrum

The n-th order moment of wave spectrum can be expressed as follows:

$$m_n = \int_0^{\infty} \omega^n S(\omega) d\omega \quad (1)$$

And there are generally two kinds of expressions for spectrum width:

$$\epsilon = \sqrt{1 - \left(\frac{m_2^2}{m_0 m_4} \right)} \quad (2)$$

$$\nu = \sqrt{\frac{m_0 m_2}{m_1^2} - 1} \quad (3)$$

where m_0 , m_1 , m_2 , m_4 are the zero, 1st, 2nd and 4th-order moment of spectrum.

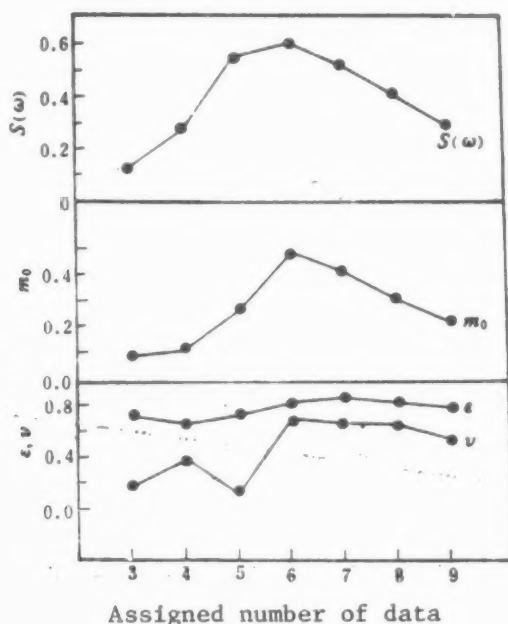


Figure 4. Time Variation of Spectrum Shape Parameters

Using the observed data and equations described above, the correlation of spectrum shape parameters and $S(\omega_M)$ was obtained by calculations (as shown in Table 3 and Figure 4). The curves in Figure 4 clearly show that changes in M_n , ϵ , and ν follow the same trend as that of $S(\omega_M)$. The fact that ϵ fluctuates between a wider range ($\epsilon = 0.6623-0.8523$) suggests that there are more high frequency components in the wind waves generated during the passing of a cold wave.

V. Discussions of the Spectrum Scale Parameters

Based on the large collections of the observed data of North Sea, Hasselmann, et al.³ proposed the JONSWAP spectrum to predict the waves of North Sea with satisfactory results. But it produced larger errors when used by Guang Yiheng [0342 2496 1854]⁴ to predict the waves of Japan Sea. This suggests that the scale parameters of JONSWAP spectrum are area-specific. Guang Yiheng proposed a modification based on the observed data of Japan Sea. Using an approach similar to Guang Yiheng's and the observed data of the Gulf of Bohai, we will discuss the changes of the spectrum parameters of the fetch-limited wind waves generated during the passing of a cold wave. In order to make comparisons of numerical values in the discussion, all quantities are converted into their non-dimensional forms. The results are as follows:

1. Correlation of $\tilde{F}$ - $\tilde{f}_m$ and $\tilde{E}$ - $\tilde{f}_m$

The correlation of non-dimensional fetch ($\tilde{F}$) and non-dimensional spectrum peak frequency ($\tilde{f}_m$), and that of non-dimensional energy ($\tilde{E}$) and $\tilde{f}_m$ were calculated from the observed data and shown in Figures 5 and 6. The following relationships were derived by using least square method:

$$\tilde{f}_m = 3.51 \tilde{F}^{-1/3} \quad (4)$$

$$\tilde{f}_m \tilde{E} = 15.12 \times 10^{-4} \quad (5)$$

in which:

$$\tilde{F} = \frac{gF}{U^2}; \quad \tilde{f}_m = \frac{Uf_m}{g}; \quad \tilde{E} = \frac{gE}{U^4}$$

where F is fetch; U wind speed; E wave energy; f_m peak frequency ($= \omega_M/2\pi$); and g acceleration due to gravity.

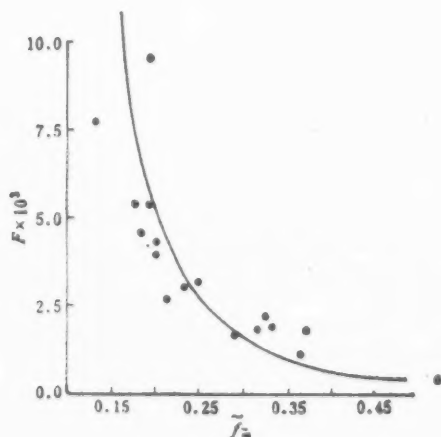


Figure 5. Correlation of $\tilde{F}$ and $\tilde{f}_m$

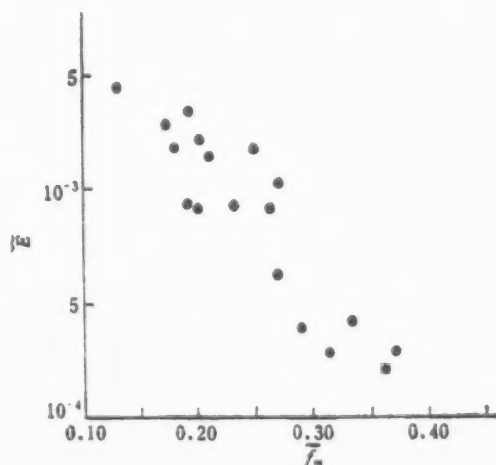


Figure 6. Correlation of $\tilde{E}$ and $\tilde{f}_m$

2. Correlations of $\alpha-\tilde{f}_m$ and $\gamma-\tilde{f}_m$

The expression for JONSWAP spectrum is:

$$S(\omega) = \alpha g^2 (2\pi) \omega^{-5} \exp \left[-\frac{5}{4} \left(\frac{\omega_M}{\omega} \right)^4 \right] \gamma \exp \left[-\frac{(\omega - \omega_M)^2}{2\sigma^2 \omega_M^4} \right] \quad (6)$$

in which the scale parameters α and γ are calculated from the following equations:

$$\alpha = \frac{2}{\omega_M} g^{-2} \int_{1.5\omega_M}^{2\omega_M} \omega^5 \exp \left[\frac{5}{4} \left(\frac{\omega_M}{\omega} \right)^4 \right] S(\omega) d\omega \quad (7)$$

$$\gamma = \alpha^{-1} g^{-2} \exp \left[\frac{5}{4} \right] \omega_M S(\omega_M) \quad (8)$$

The integration interval of equation (7) is chosen when $\gamma = 1$, that is when the measured spectrum density $S(\omega)$ reaches equilibrium, which means $S(\omega)$ basically no longer changes with fetch and wind duration. Equation (8) is derived under the assumptions that α values have been obtained from equation (7) and that $\omega = \omega_M$.

The correlation of α and $\tilde{f}_m$ and of γ and $\tilde{f}_m$ (see Figures 7 and 8) as well as the following relationships can be obtained from the observed wind wave data and equations (7) and (8):

$$\alpha = 3.3 \times 10^{-2} \tilde{f}_m^{0.6} \quad (9)$$

$$\gamma = 4.5 \tilde{f}_m^{0.7} \quad (10)$$

The correlation curves of Hasselmann's and Guang Yiheng's, whose formulas are as follows, are also presented in Figures 7 and 8.

$$\left. \begin{aligned} \alpha &= 3.3 \times 10^{-2} \tilde{f}_m^{2/3} \\ \gamma &= 3.3 \end{aligned} \right\} \text{Hasselmann} \quad (11)$$

$$\left. \begin{aligned} \alpha &= 3.26 \times 10^{-2} \tilde{f}_m^{0.7} \\ \gamma &= 4.42 \tilde{f}_m^{0.7} \end{aligned} \right\} \text{Guang Yiheng} \quad (12)$$

It can be seen from Figures 7 and 8 that our correlation curve lies between those of Hasselmann's and Guang Yiheng's.

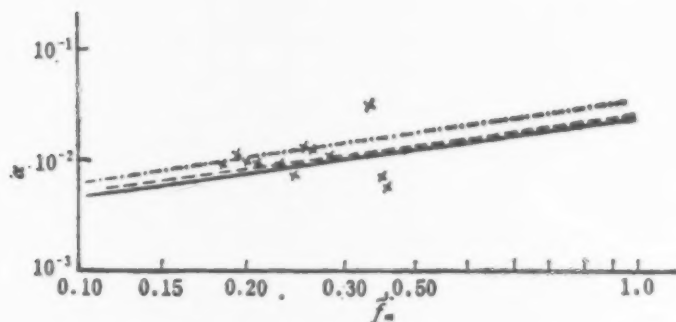


Figure 7. Correlation of α and $\tilde{f}_m$

----- Hasselmann; Guang Yiheng; — the authors

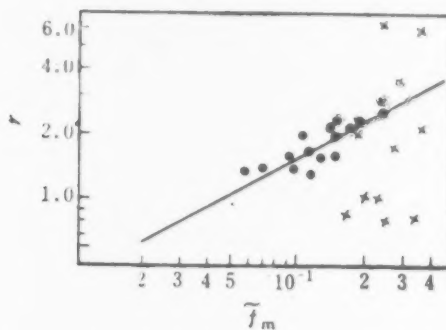


Figure 8. Correlation of γ and $\tilde{f}_m$

● Guang Yiheng; x the authors

3. Correlation of $\alpha-\tilde{F}$ and $\gamma-\tilde{F}$

Based on the observed data, the correlation of α and $\tilde{F}$ and of γ and $\tilde{F}$ were plotted (see Figures 9 and 10). The measured data of Hasselmann's and Guang Yiheng's were also included in the figures. Restrained by the topographical features of the Gulf of Bohai, the fetch measured is smaller ($\tilde{F} < 10^4$) and therefore the measured values are concentrated in a small area in the graph. Substituting equation (4) into equations (9) and (10), respectively, and the following are obtained:

$$\alpha = 9.01 \times 10^{-2} \tilde{F}^{-4/3} \quad (11)$$

$$\gamma = 7.71 \times 10 \tilde{F}^{1/7} \quad (12)$$

It can be seen from Figures 9 and 10 that observed values agree better with equations (11) and (12).

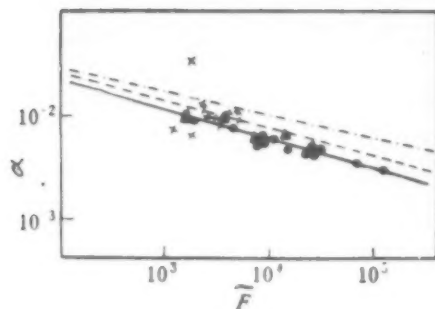


Figure 9. Correlation of α and $\tilde{F}$

▲ Hasselmann; ● Guang Yiheng; x the authors

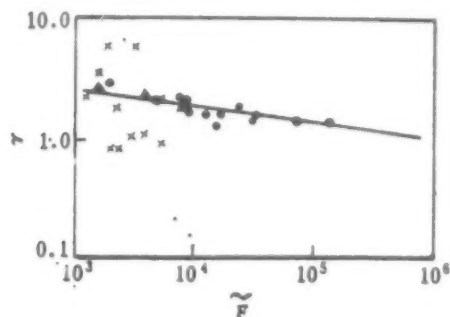


Figure 10. Correlation of γ and $\tilde{F}$

▲ Hasselmann; ● Guang Yiheng; x the authors

VI. Summary

1. During the passing of a cold wave, the waves of the Gulf of Bohai are fetch-limited. The impact of wind duration is insignificant. When a cold wave is moving south, wind speed rises and falls rapidly. Hence, the development and decay of wind waves coincide with the changes in wind speed.
2. The range of spectrum peak frequency of the cold wave generated wind waves, ω_M , is 0.8-2.5 rad/s and the maximum spectrum peak generally is no greater than $0.6 \times 10^4 \text{ m}^2 \cdot \text{s}$.
3. The spectrum width is greater with a maximum of 0.85. This suggests that there is a wider distribution of bands and that the wind waves generated by cold wave consist of not only low-frequency waves but also a large number of high-frequency ones.
4. The distribution of the spectrum scale parameters of the wind waves generated by cold wave in the Gulf of Bohai agrees better with that from Guang Yiheng's equations.

REFERENCES

1. Wave Calculation Manual, State Oceanography Bureau, 1973.
2. Guan Bingxian [4619 4426 6343], The Calculations of Maximum Wave Height of the Wind Waves at Certain Observation Sites in Southern Bohai.
3. Hasselmann, K., Ross, D.B., and Muller, P., A Parametric Wave Prediction Model, J. PHYSICS OCEANOGRAPHY, 6(2), 200-228 (1976).

12922/6091

CSO: 4008/1068

LIFE SCIENCES

ACUTE LYMPHOBLASTIC LEUKEMIA, HLA

Beijing ZHONGHUA NEIKE ZAZHI [CHINESE JOURNAL OF INTERNAL MEDICINE] in Chinese
Vol 25 No 4, 20 Apr 86 pp 217-219, 253-254

[English abstract of article by Qian Fengwei [6929 7364 0251], Ye Genyao [0673 2704 5069], Kong Fanhua [1313 4907 5478], Zeng Haiqun [2582 3189 5028], et al.,
of the 307 Hospital of the PLA]

[Text] The HLA-A, B, C antigens in 25 patients suffering from acute lymphoblastic leukemia (ALL) were compared with those of 78 normal healthy individuals in Beijing, while the HLA-DR antigens in ALL patients were compared with those in 74 normals.

The results showed that the phenotypic frequency antigens, i.e., Aw26 and Cw5 were increased in the ALL group, but only Cw5 was significantly increased in the ALL patient group ($p = 0.0133, 0.05$) when the Fisher's P value was corrected.

Our results suggested that it appears there is an HLA-Cw antigen which might be associated with ALL in the Chinese population. (Paper received 24 April 1985, finalized 27 September 1985.)

References:

- 1 钱凤伟. HLA 及其与疾病的联系. 国外医学 1979; (10):461.
- 2 赵桐茂, 等. 我国糖尿病患者 HLA 类型的分布. 中华内科杂志 1981;20:515.
- 3 Rogentine GH, et al. HL-A antigens and disease. Acute lymphocytic leukaemia. J Clin Invest 1972; 51:2420.
- 4 Johnson AH, et al. HLA and acute lymphocytic leukaemia. In: Thomson G, et al. HLA and disease ed 1, Copenhagen: Munksgaard, 1977:216.
- 5 Klouda PT, et al. Acute lymphoblastic leukaemia and HL-A: a prospective study. Tissue Antigens 1974;4:262.
- 6 Ryder IP, et al. Current trends in histocompatibility biological and clinical concepts. vol 2. ed 1, London: Plenum Press, 1981:291.
- 7 Gunz EW, Henderson ES: Leukaemia. ed 4. New York: Grune and Stratton, 1983:422.
- 8 叶微耀, 等. 我国胰岛素依赖性糖尿病患者 HLA 类型分布研究. 中华内科杂志 1984;23:469.

ENVIRONMENTAL QUALITY

WAYS TO REDUCE POLLUTION FROM BURNING COAL DETAILED

Beijing MEITAN KEXUE JISHU [COAL SCIENCE AND TECHNOLOGY] in Chinese Jul 85
pp 28-30

[Article by Zhuang Yahui [8369 0068 6540], Mao Wenyong [3029 2429 3057], and Liu Shuangjin [0491 7175 6651], of the Chinese Academy of Science Environmental Chemistry Institute: "The Effects of Coal Processing and Utilization on the Environment"]

[Text] Coal is China's primary energy resource, accounting for over 70 percent of our energy consumption. According to statistics, by the end of this century coal will make up no less than 75 percent of all our energy resources.

Right now, China's methods of utilizing coal energy are behind the times. Medium and small coal-burning facilities predominate: we have 200,000 boilers nationwide that have a capacity of less than 35 tons of steam, and 70 percent of these have a capacity of less than 4 tons. The majority of our medium and small boilers and most of the coal stoves people use burn raw coal directly, have short chimneys, and are low in thermal efficiency. In addition, they lack ash-handling and desulfurization equipment, so coal combustion gives rise to severe pollution. In particular, household coal use in urban areas, though it accounts for only 20 percent of total urban coal consumption, is responsible for more than half of the sulfur dioxide pollution in each city. Therefore, the major research problems China faces in controlling atmospheric pollution are to develop new coal utilization techniques and to solve the problem of pollution caused by coal combustion.

This article attempts a brief commentary on economically feasible technological measures that can improve efficiency in coal use and aid environmental protection.

I. Molded Coal

Coal-fired installations in China are typically small and dispersed. In terms of investment, operating costs, and technical management, it will be very difficult to install perfect ash-handling and desulfurization equipment installation by installation. Consequently, the adoption of fuel control measures and the development of molded-coal processing are proven, effective measures.

By substituting molded coal for raw coal for use in boilers, kilns, and steam locomotives, 10 to 15 percent can generally be saved on coal and the volume of particulates and sulfur dioxide discharged can be distinctly reduced. Based on China's experience, although using molded coal is less environmentally beneficial than employing coal gasification or liquefaction, a comprehensive evaluation of environmental, energy-saving, and economic factors shows that it is still the fastest and cheapest way of controlling atmospheric pollution caused by coal combustion. The environmental benefits of coal processing are charted below:

Table 1. The Environmental Benefits of Coal Processing

Coal Processing Technique	% Reduction in Particulate Discharge	% Reduction in Sulfur Dioxide Discharge
Raw coal combustion	0	0
Coal dressing	0	50
Coal molding	30-60	30-60
Gasification	95	95
Fluidized-bed combustion	-	95
Coal slurry	-	90
Smoke and vapor desulfurization	-	85-95

Table 2. An Evaluation of Molded Coal Investment Benefits

Annual molded coal volume	6 million tons
Investment	3.4 million yuan
Unit price	51 yuan/ton
Reduction in particulate discharge	30 percent
Reduction in sulfur dioxide discharge	30 percent
Volume of coal saved per year	.8 million tons

In terms of molded coal for industrial and household use in China, there are now 18 kinds of molded coal for use in boilers, kilns, and household cooking and heating; 12 kinds of bonded coal are officially in use, including natural products and industrial products; 3 kinds of standardized molded-coal processing equipment have been put into use; and some corresponding furnace implements for molded coal have been developed.

II. Fluidized-bed Combustion

Coal mines in China remove 60 to 70 million tons of waste rock each year, and coal washing plants also discharge 20 to 30 million tons of waste rock. Nationwide, over 1 billion tons of waste rock have been accumulated over the years--waste rock that has a calorific value of 1,000 to 2,000 kcal/kg. If this huge volume of mining waste is not disposed of appropriately it may give rise to pollution through spontaneous combustion or leaching.

This kind of low caloric fuel can be burned using fluidized bed combustion.

The development of fluidized-bed combustion in China is based primarily on the following considerations:

1. Various fuels that have a high ash content, high water content, low caloric value, or low volatility, such as oil shale, coal gangue, inferior coal, lignite, combustible slag, and so forth, can be burned using fluidized bed combustion. Most of the fluidized beds currently in use in China burn inferior coal. Bone coal from southern China has a high ash content and a low calorific value. Using ordinary means of combustion it is very difficult to burn and produces severe pollution, but this abundant resource can be utilized by employing fluidized beds. Fluidized beds are also particularly suitable for use in pithead power plants that burn coal gangue or washed coal.

2. In a fluidized bed, sulfur can be removed during combustion and abundant, inexpensive lime can be used as a desulfurizing agent. In addition, a fluidized bed burns at a low temperature, which is helpful in reducing the volume of hydroxides [as published] discharged. Southwest China produces a great deal of high-sulfur coal and possesses acidic soil, so acid rain poses a serious threat. In that area fluidization is an environmentally beneficial coal-use technique that provides an option.

3. The price of fluidized beds fluctuates little with the scale of the undertaking, and this is favorable for small-scale combustion. In China small-scale, dispersed industrial boilers and kilns account for approximately half of all the coal consumed, and this dispersion increases administrative problems. The development of fluidized beds is helpful in resolving pollution problems associated with the small-scale dispersed boilers that are still widespread in China.

4. The investment required for fluidized beds is relatively low, making them suitable for development in China. Fluid beds may increase combustion efficiency; they are a combustion method that makes coal burning more economical.

Operating costs have been calculated for representative fluidized-bed boilers. Their economic and environmental benefits are listed below:

Table 3. Fluid Bed Costs for Boilers Burning 10 t/h of Coal

Coal cost	450,000 yuan/year
Lime cost	88,000 yuan/year
Water and electricity costs	80,000 yuan/year
Depreciation and administrative costs	610,000 yuan/year
Reduction in sulfur dioxide	96 percent
Capital investment	380,000 yuan

Note: Caloric value is 4,000 kcal/kg; sulfur content is 3 percent; sulfur dioxide concentration at entry is 2,000 ppm; sulfur dioxide concentration at exit is 750 ppm.

III. Routine Smoke Desulfurization at Coal-fired Power Stations

About one-fifth of the sulfur dioxide now discharged annually into the atmosphere in China comes from thermal power plants. According to statistics,

by the end of the century thermal power plants may use more than 300 million tons of coal, and the average sulfur content of the raw coal used will rise from the current 1.4 percent to 2 percent. Thus, annual sulfur dioxide emissions may exceed 8 million tons, leading to environmental pressures that cannot be ignored.

Right now, due to the high sulfur content of coal and the inability of coal washing to meet thermal power plant requirements for raw coal desulfurization, in some areas of China smoke emissions seriously exceed standards and, as a consequence, construction of certain power plants has been restricted.

China's flue desulfurization system for coal-fired power plants is still in various stages of development. From the lab it will enter immediately into intermediate trials or full-scale equipment testing. As yet there is no example of industrial application of this system. Some tests have indicated that installing smoke desulfurization equipment at power plants burning high sulfur coal offers distinct environmental and social benefits.

Because thermal power plant smoke desulfurization calls for a fairly high investment, entails high costs, and requires difficult, composite technology, our policy is to explore further, based on our own trials, the environmental and economic benefits and then build demonstrator industrial installations. Right now we are conducting selective comparisons on three technologies: a dry spray absorption method, a limestone wet washing method, and an ammonium phosphate fertilizer method. A preliminary economic analysis of smoke and vapor desulfurization conducted on a typical 25,000 kW unit follows:

Table 4. An Economic Comparison of 3 FGD [Flue-gas Desulfurization] Methods

Method	Dry Spray Absorption	Limestone Wet Scrubbing	Compound Ammonium Phosphate Fertilizer
Investment (yuan)	960,000	1,920,000	4,500,000
Absorbent cost (yuan/year)	576,000	158,000	277,000
Water, electricity costs (yuan/year)	43,500	310,000	206,000
Depreciation cost (yuan/year)	48,000	96,000	225,000
Operator labor cost (yuan/year)	42,000	144,000	12,000
Maintenance, management costs (yuan/year)	8,000	17,000	17,500
Recovered in by-product sales (yuan/year)	discarded	discarded	1,684,000

Note: Calculated based on a 25,000 kW capacity; rate of sulfur dioxide elimination is 85 percent.

When costs of dust collection and design are not included, these three methods are basically economical to the same degree.

IV. Washing

Coal washing brings multiple benefits, including desulfurization, reduction in ash content, and improvement in coal quality. These are not only economically beneficial, they also favor environmental protection. At present only a small proportion of coal in China is washed, in some provinces and autonomous regions less than 10 percent. Nationwide, due to the lack of coal washing and by-product recovery, the major collieries annually add to waste rock and coal ash by 70 million tons and 100 million tons, respectively. The 20 million tons of smoke particulates and 12 million tons of sulfur dioxide create heavy losses. For example, in Henan 44 million tons of coal were consumed in 1978, and over 90 percent of this was raw, unwashed coal. By comparison with the thermal energy utilization ratio produced by washed coal, a total of 12 million-plus tons of coal was wasted provincewide and 8 million tons of coal ash, 1.3 million tons of smoke particulates, and 1.2 million tons of sulfur dioxide were produced. Thus, the quantity of coal ineffectively transported was increased by 6 million tons, and accumulated economic losses reached to over 100 million yuan.

China currently produces about 100 million tons of high-sulfur coal (over 2 percent sulfur content) per year, and southwestern coal, in particular, is largely high-sulfur coal. Due to the lack of coal washing sulfur dioxide pollution is severe and the area has become a major acid rain region, corroding construction materials and endangering agricultural production.

As described above, China's energy-using installations are typically small and dispersed, so controlling fuel sulfur content is the preferred desulfurization measure. Based on preliminary calculations, to build a washing plant capable of handling 1 million tons of high-sulfur coal per year, if we figure a 20 yuan investment for each ton of coal we will need to invest 20 million yuan. Add in pyrite sulfur recovery equipment, and we will need another 3 million yuan. This kind of sulfur recovery unit can annually produce 20,000 to 30,000 tons of sulfur concentrate, worth 1.3 to 2 million yuan, and raise economic results by 1 to 1.7 million yuan. Thus, it is economically feasible and can also increase China's sulfur resources.

Coal washing is one major measure widely adopted by various nations to protect their environments, and it is also practical on a wide scale in China. However, due to economic and technical limitations, it is still difficult to implement in a comprehensive fashion. In the near future we should first pursue high-sulfur coal washing, develop a rational technique for utilizing washed gangue, recover sulfur resources from coal, and prevent pollution from gangue washing.

V. Coal Slurry

Relevant work on slurry combustion is still in the research and development phase in China. It is advantageous to use fuel oil as an industrial chemical or an export, and it will partially replace coal as a basic fuel. In hydraulic coal mining and in the washing process, coal may partially become coal slurry. Consequently, there are bright prospects for this fuel in

industrial boilers, kilns, and power stations. Combustion tests China has conducted on coal slurry indicate that a mixed fuel slurry composed of 65 to 70 percent dry coal can burn in a stable fashion and reach over 95 percent carbon conversion.

The primary environmental impact is brought about by the discharge of particulates, sulfur dioxide, and nitrogen dioxide. We have conducted an analysis to compare flue gas from coal slurry combustion and from fuel oil combustion, using the same boiler. When coal slurry is substituted for petroleum, environmental concentrations of sulfur dioxide may be greatly increased. Testing indicates that dolomite and limestone additives must be used to ensure relatively efficient desulfurization.

Coal slurry combustion and fuel oil combustion in boilers have the following environmental effects:

Table 5. A Comparison of the Effects of Coal Slurry Combustion and Fuel Oil Combustion in Boilers

	Oil	Slurry No 1	Slurry No 2
Slurry coal concentration (%)	--	61.2	72.0
Flue CO ₂ concentration (%)	7.6-8.7	13.2	7.1-12.0
Flue NO _x concentration (ppm)	25-35	0.20	10
Flue SO ₂ concentration (ppm)	70-125	--	160-350
Flue CO concentration (ppm)	280-480	--	500-3,000
Flue particulate density (g/Nm ³)	0.65-1.29	3.43	--
Flue hydrocarbon density (ppm)	120-240	--	120

In the coal slurry combustion technique NO_x can be reduced 12 percent due to the low temperature of the flames. The nitrogen content of the fuel and the state of combustion within the boiler both affect the discharge of NO_x. Particulate discharge in slurry combustion is higher by one level of magnitude than that in fuel oil combustion. Thus, we must improve the efficiency of dust removal in existing equipment or manufacture new dust-removal equipment.

Conclusions:

1. The condition of Chinese coal resources and usage and the state of the environment in China are very complex. No specific technology or technique can completely resolve environmental problems caused by coal combustion. We should conduct a comprehensive analysis, weigh the advantages and disadvantages, and choose and apply suitable techniques.
2. The use of molded coal is a simple and effective means to quickly improve combustion efficiency and alleviate atmospheric pollution brought about by coal combustion. It is worthwhile to enhance research and dissemination of this method. Right now we should work particularly hard to study and disseminate low-pollutant molded coal processing and smokeless technology.

3. Techniques for washing and desulfurizing high-sulfur coal and recovering sulfur resources are of major economic and environmental significance in southern China. This sulfur dioxide control tactic should be given priority consideration; we are in urgent need of a technological breakthrough in this area.

4. Medium and small boilers in high-sulfur coal regions should switch to fluidized-bed combustion, solve problems that exist with fluidized-bed ash and cinder disposal and dust removal, and improve thermal efficiency. Use of fluidized beds can then expand into combustion of coal with a high calorific value. This is the primary way to handle the gravity of pollution from China's scattered small boilers.

5. In high-sulfur coal regions and in areas in which the meteorological and geographical conditions are not conducive to smoke and vapor diffusion, coal-fired power plants should install flue-gas desulfurization devices. In this comprehensive and intense endeavour, all domestic sectors must enhance cooperation and tackle key problems. We must also draw on the experiences of other nations and augment international exchange and cooperation.

12510

CSO: 4008/2108

Engineering Thermophysics

EQUATION OF STATE FOR MOLECULAR AGGREGATION (OR ASSOCIATION) (MODEL FOR AGGREGATED HARD SPHERICAL MOLECULES)

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 7 No 2, May 86 pp 93-98

[English abstract of article by Tong Jingshan [4547 2529 1472], et al., of Qinghua University]

[Text] In this paper we propose the theory of molecular aggregation (or association) and apply it to improve some equations of state. To prove the correctness of this theory and effectiveness of the proposed improvement the saturated vapor volume data of 30 substances (including strongly polar and associated compounds, such as ammonia, water methanol, ethanol, acetic acid, etc.) were calculated and compared with experimental data. The calculated results show that the improved equations are fairly fitted to the experimental data and also that the molecular aggregation theory developed by the authors is correct.

TRANSONIC CASCADE FLOW SOLVED BY SHOCK-CAPTURE COMPUTATION FOLLOWED BY
SEPARATE-REGION COMPUTATION WITH SHOCK FITTING

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 7 No 2, May 86 pp 112-119

[English abstract of article by Wu Zhonghua [0702 0112 5478], et al., of the
Institute of Engineering Thermophysics, Chinese Academy of Sciences]

[Text] A new method is presented in this paper to solve the transonic flow past a compressor cascade in which the effect of the inlet bow wave and passage shock is considered, with the flow downstream being either subsonic or transonic. The computation consists of two steps. In the first step, a shock capturing solution is obtained by the use of a potential equation or stream function. The passage shock position obtained by either one or the average of the two is used as the starting value in the second step. In the second step, separate algorithms are used, respectively, for the supersonic flow upstream of and the subsonic or transonic flow downstream of the passage shock. The passage shock is adjusted after each cycle of calculation until the Rankine-Hugoniot relationships are satisfied. The axial-velocity density ratio and the increase in entropy due to the viscous effect downstream of the passage shock are also considered in the second step.

Calculations are made for a typical double-circular-arc cascade at inlet Mach numbers varying from 1.03 to 1.34. The effects of the axial-velocity density ratio and entropy increase downstream of the passage shock are clearly shown. The pressure distribution around the blade profile calculated with proper values of the axial-velocity density ratio and entropy increase compares favorably with the experimental data.

APPROACH TO AEROTHERMODYNAMIC PERFORMANCE PREDICTION OF GAS TURBINES
CONTAINING WET STEAM CONDENSATION

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 7 No 2, May 86 pp 130-132

[English abstract of article by Ling Zhiguang [0407 1807 0342], et al., of
the Institute of Engineering Thermophysics, Chinese Academy of Sciences; and
Fei Yang [6316 2254] of the Institute of Silicates, Chinese Academy of Sciences]

[Text] After introducing the basic relationships and fundamental equations of
gas turbines containing wet steam condensation, a simple method is suggested
based on replacing the condensation and heat release process thermodynamically
by an equivalent polytropic process such that the usual gas medium calculation
program can be employed and performance prediction can easily be made. The
calculated performance of such a turbo expander shows good agreement with
tested results.

EXPERIMENTAL INVESTIGATION OF COMPOSITE COOLING ON LEADING EDGE REGION OF
TURBINE BLADE

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 7 No 2, May 86 pp 147-150

[English abstract of article by Ji Honghu [0679 3163 3275], et al., of Nanjing
Aeronautical Institute]

[Text] A semi-cylinder with film holes is used to simulate the impingement
and film cooling on the leading edge region of a turbine blade. It is found
that the impingement cooling on the concave surface is enhanced with the
existence of film holes, and the film cooling effectiveness is evidently
increased with the laterally slanted film holes.

NUMERICAL SOLUTION OF FLOW FIELD OF SHORT-ANNUAL COMBUSTION CHAMBER

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 7 No 2, May 86 pp 176-178

[English abstract of article by Xu Hang [1776 5887], et al., of Beijing
Institute of Aeronautics and Astronautics]

[Text] The recirculating flow field of a short-annual combustion chamber has been studied. The body-fitting coordinate system and the "simple" method combined with a constant viscosity model have been employed to solve the Navier-Stokes equations in cases where a complicated curved boundary exists. The results could provide the theoretical reference for the design and improvement of the short-annual combustion chamber.

9717

CSO: 4009/83

4 August 1986

Nuclear Techniques

THE TDCR METHOD FOR ACTIVITY STANDARDIZATION IN LIQUID SCINTILLATION COUNTING

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 5, May 86 pp 1-7, 58

[English abstract of article by Lan Yunxia [5663 0060 7209], et al., of Shanghai Institute of Nuclear Research, Chinese Academy of Sciences]

[Text] A new method for radioactivity standardization in liquid scintillation counting is described. In the method a triple to double coincidence ratio was taken for a reference quantity of efficiency change and the coincidence counting was extrapolated to the value of TDCR = 1, thus possibly leading directly to an approximate value for the sample activity.

This paper describes the principle of the method, the efficiency calculation and the estimate of the uncertainty. The measured results for tritiated water coincide with the nominal value of the NBS standard within an uncertainty of ± 0.63 percent.

INVESTIGATION OF TUNGSTEN SILICIDE FORMED BY As ION BEAM MIXING WITH
RUTHERFORD BACKSCATTERING

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 5, May 86 pp 13-18, 12,
58-59

[English abstract of article by Wang Zhonglie [3769 1813 3525], et al., of
the Low Energy Nuclear Physics Institute, Beijing Normal University]

[Text] The conditions for forming tungsten silicide with As ion beam mixing have been studied by means of Rutherford backscattering. A comparison between sintering and ion beam mixing is made. The phases have been identified by X-ray diffraction. The results demonstrate that the refractory metal silicide may be formed at a reduced reaction temperature using the ion beam mixing technique. The effect of oxygen impurity on silicide formation is observed. Finally, the mechanism of the formation of the silicide by ion beam mixing is discussed.

DISCRIMINATING α PARTICLES FROM PROTONS WITH SOLID STATE TRACK DETECTOR

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 5, May 86 pp 24-26, 42, 59

[English abstract of article by Jin Weiguo [6855 5898 0948], et al., of Fudan University]

[Text] In this paper a comparison is made of the general properties of a Chinese-made cellulose nitrate and two kinds of cellulose acetate films with different thicknesses in discriminating α particles from protons. The 140 μm cellulose acetate film is selected as the solid state track detector used in nuclear lifetime measurement by the blocking effect.

MECHANISM OF ACOUSTIC EMISSION GENERATED BY HIGH ENERGY CHARGED PARTICLES
IN LIQUIDS

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 5, May 86 pp 41-42, 61

[English abstract of article by Liu Yongyue [0491 3057 6885] of the Institute
of High Energy Physics, Chinese Academy of Sciences]

[Text] The origins of the inconsistencies in the experimental data are
analyzed. An analytical method is proposed, and the acoustic generation
mechanism in liquids is examined. The results are inconsistent with any
significant contribution from either microbubble formation or molecular
dissociation. The thermoacoustic mechanism is dominant.

9717

CSO: 4009/84

Optics

RAMAN SPECTRA AND SYMMETRY OF $\text{LiZnTa}_3\text{O}_9$ CRYSTAL

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86
pp 391-395

[English abstract of article by Lan Guoxiang [5663 0948 4382], et al., of
the Department of Physics, Nankai University, Tianjin]

[Text] Raman spectra of $\text{LiZnTa}_3\text{O}_9$ crystal have been obtained for the first
time and compared with those of LiTaO_3 . Forward-Raman scattering shows that
there is no polariton dispersion in $\text{LiZnTa}_3\text{O}_9$, thus we can conclude that the
symmetry of $\text{LiZnTa}_3\text{O}_9$ crystal is the D_{3d} point group. Finally, Raman spectra
of $\text{LiZnTa}_3\text{O}_9$ are assigned and discussed.

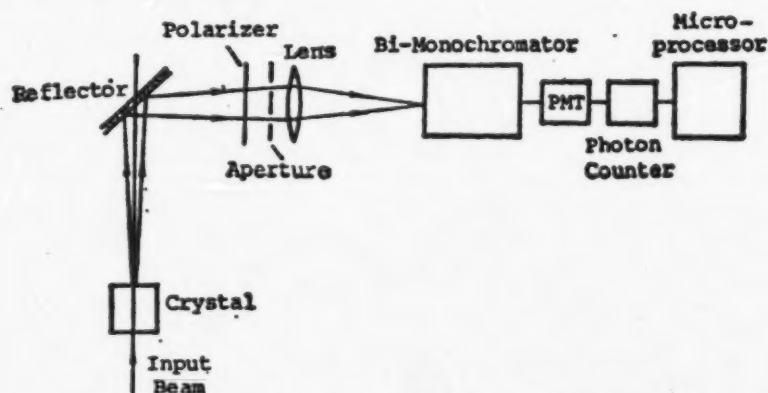


Fig. 1 Experimental arrangement for forward-Raman scattering

OPTOGALVANIC SPECTROSCOPY IN Eu HOLLOW CATHODE DISCHARGE

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86 pp 396-401

[English abstract of article by Jing Chunyang [2529 2504 7122], et al., of the Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] A CW tunable dye laser was used to measure the optogalvanic spectroscopy of Eu. Sixty-five spectral lines were observed, 61 of which were from EuI and 4 from EuII.

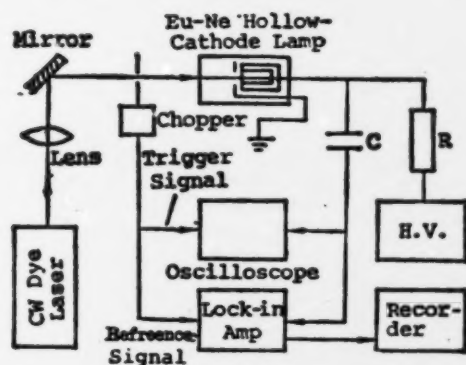


Fig. 1 Block diagram for measuring the optogalvanic spectroscopy of Eu

HIGH EFFICIENCY FREQUENCY TRIPLING OF 1.06 μm LASER RADIATION

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86 pp 413-419

[English abstract of article by You Chenhua [1429 2525 5478], et al., of the Department of Optical Instruments, Zhejiang University, Hangzhou]

[Text] In this paper coupled wave equations are solved for large signals by means of numerical integration. A numerical method for calculating SHG and THG efficiencies of beams with Gaussian temporal profiles is given. A high efficiency frequency tripling scheme for low and moderate power levels is presented. With type I $\beta\text{-BaB}_2\text{O}_4$ crystal used in doubling and type II KD*P used in tripling, energy conversion efficiencies of THG as high as 41.8 percent have been achieved at an energy level of 365 mJ.

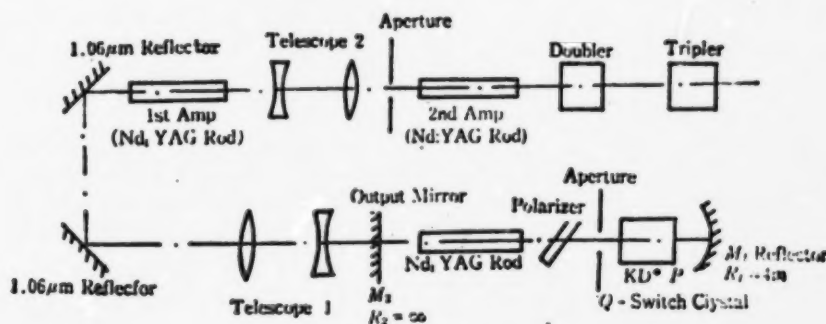


Fig. 7 Setup for THG experiment

STUDIES ON MULTI-PHOTON OPTICAL BISTABILITY

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86
pp 427-432

[English abstract of article by Weng Zhaoheng [5040 0340 1854] of Changchun Institute of Optics and Fine Mechanics, Chinese Academy of Sciences; Ma Aiqun [7456 1947 5028], et al., of Harbin Institute of Technology]

[Text] In this paper a quantum mechanics model for describing multi-photon optical bistability is given. Based on this model, the state equation of multi-photon optical bistability is obtained. The method used for calculating the threshold of multi-photon optical bistability is also given. After analyzing the potential function, we obtain the static stability criterion and the explanation of switching characteristics. The stable region and inferior stable region in the bistability characteristic curve are separated. In fact, multi-photon optical stable states are actually multi-photon optical stable-inferior stable states. We also discuss the phase transition problem of multi-photon optical bistability and multi-photon lasers.

WIDE ANGLE AND GREAT SCENE HOLOGRAPHY

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86
pp 433-439

[English abstract of article by Xing Liangling [1630 5328 2733], et al., of
the Laser Research Institute, Suzhou University]

[Text] The present work is based on the teaching materials of experimental holography given by Professor J. Upatnieks and used at the Electrical and Computer Engineering Department, University of Michigan. After making some improvements in the optical system according to the experimental conditions in our institute, we succeeded in taking several wide angle and great scene holograms of Suzhou garden models (120 visual angle, 250 cm depth and 100 x 250 cm area), and obtained a bright and sharp three-dimensional reconstructed image. Therefore, this technique provides a cheap and practical method for taking holograms of great visual angle and scene in engineering structures, holographic displays, advertisements, artistic photography, data-storage, etc.

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CSO: 4009/85

Semiconductors

CARRIER TRANSPORT IN HETEROSTRUCTURE BASE REGION AND CARRIER CONFINEMENT
FACTOR IN LASING REGION OF GaAs/GaAlAs PNP LASER

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 3, May 86 pp 227-236

[English abstract of article by Zhang Quansheng [1728 2938 3932] and Wu
Ronghan [0702 2837 3352] of the Institute of Semiconductors, Chinese Academy
of Sciences]

[Text] By solving the continuous equation, the carrier transport character-
istics in the heterostructure base region of the transistor (DH laser struc-
ture contained) in a GaAs/GaAlAs pnpn laser designed by the authors have been
analyzed, with the carrier confinement factor in the lasing region given.
(Paper received 6 March 1985.)

REFERENCES

- [1] 王守武、吴崇汉、朱其高、张权生、李耀德、田慧良,电子学报, 3,35(1979).
- [2] H. C. Casey and M. B. Panish, Heterostructure Lasers, Academic Press. Part. A, 193(1978).
- [3] R. D. 密特布洛克(美)著,“面结型晶体管导论”,国防工业出版社, p.284, (1966).
- [4] H. C. Casey, Jr. *J. Appl. Phys.*, 49, 3684(1978).

CALCULATION OF SPREADING RESISTANCE CORRECTION FACTORS BY PIECEWISE
QUADRATIC FUNCTION INTERPOLATION

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 3, May 86 pp 242-247

[English abstract of article by Shu Chang [5289 2545] and Bao Zongming [0545
1350 2494] of Fudan University]

[Text] Piecewise quadratic function interpolation is proposed for the calculation of spreading resistance correction factors. The method is fast and highly accurate in calculations using a computer with small memory storage. It is very suitable for calculations by microcomputers. It takes 4 seconds to calculate a correction factor and less than 15 minutes to correct 35 data points on an Apple II in BASIC. (Paper received 20 March 1985.)

REFERENCES

- [1] P. A. Schumann and E. E. Gardner, *J. Electrochem. Soc.*, 116, 87(1969).
- [2] T. H. Yeh and K. H. Khokhani, *ibid*, 116, 1461(1969).
- [3] S. M. Hu, *Solid-State Electronics*, 15, 809(1972).
- [4] Y. Lida and H. Abe, *J. Electrochem. Soc.*, 124, 1118(1977).
- [5] S. C. Choo, M. S. Leong, H. L. Hong, L. Li and L. S. Tan, *Solid-State Electronics*, 21, 769 (1978).
- [6] Donald C.D. Avanzo, Robert, D. Rung, Arnon Gat and Robert W. Dutton, *J. Electrochem. Soc.*, 125, 1170(1978).
- [7] S. C. Choo, M. S. Leong and L. S. Tan, *Solid-State Electronics*, 24, 557(1981).
- [8] H. L. Berkowitz and R. A. Lux, *J. Electrochem. Soc.*, 128, 1137(1981).
- [9] H. L. Berkowitz and R. A. Lux, *ibid*, 126, 1479(1979).
- [10] R. G. Manz and G. A. Gruber, *Solid State Technology* November 1981, 64.

ELECTRONIC STRUCTURE OF α - Al_2O_3 -Si INTERFACE

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 3, May 86 pp 248-253

[English abstract of article by Shen Qing [3088 3237], et al., of the
Department of Physics, Sichuan University]

[Text] A DV-SCC- X_α method is used to calculate the electronic structure of an α - Al_2O_3 -Si interface. The method, model and results are discussed. The results calculated, such as electric conductivity, energy gap and state density, are in good agreement with the experimental data. (Paper received 27 March 1985.)

REFERENCES

- [1] 全国第三届表面与界面论文集, 西安. (1984).
- [2] D. E. Ellis and G. S. Painter, *Phys. Rev.* 2, 2887(1970).
- [3] E. J. Bacrends, D. E. Ellis and P. Ros, *Chem Phys.* 2, 41(1973); 8, 412 (1975).
- [4] 唐放庆等, 量子化学, 科学出版社, (1980).
- [5] R. Rosen, D. E. Ellis, H. Adachi and F. W. Averill *J. Chem. Phys.* 65, 3629 (1976).
- [6] M. Jaros, *Deep Levels in Semiconductor*, Adam. Hilger Ltd., Bristol, (1982).
- [7] M. L. Kronberg, *Acta. Met.* 5, 507(1957).
- [8] J. C. Slater, *Quantum Theory of Molecules and Solids* vol. 2, McGraw-Hill Book Company (1965).
- [9] H. Schlöterer, *J. Vac. Sci. Tech.* 13, 29(1976).
- [10] H. Thomas IV. *Surface and Interface Anal.* 4, 156(1982).
- [11] J. D. Filby and S. Nielsen *Brit. J. Appl. Phys.* 18, 1357(1967).
- [12] J. L. Porter, *J. Appl. Phys.* 36, 2746(1965).
- [13] E. T. Arakawa and M. W. Williams. *J. Phys. Chem. Solids*, 29, 735(1968).
- [14] G. J. Diens, D. O. Welch, C. R. Fischer, R. D. Hatcher, O. Lazareth and M. Samberg, *Phys. Rev.* B11, 3060(1975).
- [15] D. E. Ellis, G. A. Benesh and E. Byrson, *Phys. Rev.* B20, 1198(1979).

ADMITTANCE ANALYSIS OF DX CENTERS IN Te-DOPED LPE n-TYPE AlGaAs MATERIAL

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7 No 3, May 86 pp 254-263

[English abstract of article by Ge Weikun [5514 1919 6924], et al., of the Institute of Semiconductors, Chinese Academy of Sciences]

[Text] We have measured the DX centers in LPE n-type $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}:\text{Te}$ samples by both DLAS and DLTS techniques. Two energy levels which might be associated with the DX center were resolved: $\Delta E_{\text{em}} = \sim 0.35$ eV and ~ 0.20 eV, $\Delta E_{\text{eq}} = \sim 0.10$ eV and ~ 36 meV, respectively. (Paper received 8 April 1985.)

REFERENCES

- [1] D. L. Losee, *Appl. Phys. Lett.*, **21**, 54(1972).
- [2] D. L. Losee, *J. Appl. Phys.*, **46**, 2204(1975).
- [3] J. L. Pautrat, B. Katircioglu, N. Magnea, D. Bensahel, J. C. Pfister and L. Roval, *Solid State Electronics*, **23**, 1159(1980).
- [4] D. V. Lang, R. A. Logan and M. Jaros, *Phys. Rev.*, **B19**, 1015(1979).
- [5] D. V. Lang and R. A. Logan, *Inst. Phys. Conf.*, **43**, 433(1979).
- [6] D. V. Lang and R. A. Logan, *Phys. Rev. Lett.*, **39**, 635(1977).
- [7] J. Bourgoin and Lannoo, *Point Defects in Semiconductors II* Springer-Verlag (1983).
- [8] R. H. Wu (吳榮漢) and A. R. Peaker *Solid State Electronics*, **23**, 643(1982).
- [9] M. Derdouri, L. Mahdjoubi and M. Benmalek, *Solid State Electronics*, **23**, 925 (1982).
- [10] A. K. Saxena, *J. Electronic Materials*, **11**, 453(1982).
- [11] 王家祥等, 半导体器件物理, 科学出版社(1983).
- [12] R. J. Nelson, *Appl. Phys. Lett.*, **51**, 351(1982).
- [13] A. J. Springthorpe, F. D. King and A. Becker, *J. Electronic Materials*, **4**, 101(1975).
- [14] J. J. Yang, L. A. Monday and W. I. Simpson, *Appl. Phys. Lett.*, **40**, 244(1982).
- [15] H. Künzel, A. Fischer, J. Knecht and K. Ploog, *Appl. Phys.*, **A32**, 69(1983).
- [16] O. Kumagai, H. Kawai, Y. Mori and K. Kaneko, *Appl. Phys. Lett.*, **45**, 1322(1984).
- [17] E. H. Rhoderick, *Metal-Semiconductor Contacts*, Oxford (1980).
- [18] G. Vincent, D. Bois and P. Pinard, *J. Appl. Phys.*, **46**, 5173(1975).
- [19] M. Minuts, M. Tachikawa, H. Kukimoto and S. Minomura, *Jpn. J. Appl. Phys.*, **24**, L143(1985).

FREQUENCY DEPENDENCE OF CAPACITANCE DERIVATIVES IN MOS CAPACITOR--NEW METHOD FOR DETERMINING THE DENSITIES AND CAPTURE CROSS SECTION OF SURFACE STATE AT Si-SiO₂ INTERFACE

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7 No 3, May 86 pp 264-274

[English abstract of article by Xu Mingzhen [6079 6900 4176], et al., of the Department of Computer Science and Technology, Beijing University]

[Text] The frequency dependence of capacitance derivatives in an MOS capacitor based on a single energy model and distributed energy model and the influence of random fluctuations of charge are discussed. The normalized analytic expressions are obtained. The densities, energy distribution and capture cross section of the surface state at the Si-SiO₂ interface may be determined simultaneously from the spectrum. This method has some advantages and is analogous to the conductance technique. The experimental results are consistent with the theoretical calculations. (Paper received 6 March 1985.)

REFERENCES

- [1] K. Lehovec, *Appl. Phys. Lett.*, **8**, 48 (1966).
- [2] E. H. Nicollian and A. Goetzberger, *Bell. Syst. Tech. J.*, **46**, 1055(1967).
- [3] A. Goetzberger, E. Krausmann, M. J. Scholz, *CRC Critical Reviews in Solid State Sciences*, **6**, 1 (1976).
- [4] A. Singh and J. G. Simmons, *Solid State Electron.*, **25**, 219 (1982).
- [5] M. Kuhn, *Solid State Electron.*, **13**, 873(1970).
- [6] R. Castagne and A. Vapaille, *Surf. Sci.*, **28**, 157(1971).
- [7] R. H. Kingston and S. F. Neustadter, *J. Appl. Phys.*, **26**, 718(1955).
- [8] A. S. Grove, B. E. Deal, E. H. Snow and C. T. Sah, *Solid State Electron.*, **8**, 145(1965).
- [9] F. P. Heiman, *IEEE Trans on Electron Devices*, ED-13, 835(1966).
- [10] A. G. Kokkas, *Solid State Electron.*, **25**, 249(1982).
- [11] Model 410 C-V Plotter operating and Service manual IV-15 (1981).
- [12] 邵长华等, 半导体技术, No. 4, 37(1984).
- [13] 史常忻、陆德仁、顾为芳, 半导体学报, **2**, 161(1981).

CHANNEL ROUTING ALGORITHM USING HYBRID GRAPH

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 3, May 86 pp 292-297

[English abstract of article by Zhou Dian [0719 7193], et al., of the
Department of Electrical Engineering, Fudan University]

[Text] This paper presents a hybrid graph model containing both directed and undirected edges for channel routing. Two algorithms have been established on the basis of this model. The algorithms take into account the global characteristics of constraints and develop a method which transforms the horizontal constraint into vertical ones, taking into consideration the relationship between the two kinds of constraints. In assigning a net segment to the track, the algorithms put an emphasis on the relativity of the net segment by putting off the earlier determination of the final position of the segments. In this case, the uncertainty in the assignment process can be avoided. The results calculated for some selected benchmark problems are the best yet determined. (Paper received 29 May 1985.)

REFERENCES

- [1] Hashimoto-Stevens, Proc. of 8th DAC, 135(1971).
- [2] B. W. Kernighan, D. G. Schweikert, G. Persky, Proc. of 10th DAC, 90(1973).
- [3] W. W. Wade, Proc. of 18th DAC, 762(1981).
- [4] R. L. Rivest and C. M. Fiduccia, CAD, 13, 135(1983).
- [5] W. S. Chan, Third Caltech Conference on VLSI, 117(1983).

METHOD FOR ELECTRICALLY ACTIVATING THE COPPER IN SILICON

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7
No 3, May 86 pp 308-313

[English abstract of article by Chen Kaimao [7115 7030 5403] of the Department of Physics, Beijing University; and Qian Simin [6929 1835 2404], et al., of the Low Energy Institute, Beijing Normal University]

[Text] Only a very small proportion of copper in silicon is electrically active and, therefore, it cannot generally be detected. A method is suggested for activating the copper in silicon with electron irradiation and detecting it by DLTS. It is useful for detecting trace copper in silicon. A formula which can be used to estimate the average density of deep levels quite accurately is also suggested. (Paper received 6 March 1985.)

REFERENCES

- [1] R. N. Hall and J. H. Racette, *J. Appl. Phys.*, **35**, 379(1964).
- [2] J. W. Chen and A. G. Milnes, *Ann. Rev. Mater. Sci.*, **10**, 157(1980).
- [3] A. A. Lebedev and M. M. Akhmedova, *Sov. Phys. Semicond.*, **10**, 1130(1977).
- [4] 陈开亨, 康国刚, (待发表).
- [5] 陈开亨, 王忠安, (待发表).
- [6] E. R. Weber, *Appl. Phys.*, **A30**, 1(1983).

AUGER AND PHOTOELECTRON SPECTRUM STUDIES OF GaAs AND InP THIN ANODIC FILMS

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7 No 3, May 86 pp 314-318

[English abstract of article by Zhou Mian [0719 0517], et al., of Shanghai Institute of Metallurgy, Chinese Academy of Sciences]

[Text] GaAs and InP thin anodic films with uniform thickness and good repeatability are obtained by using a newly developed solution of anhydrous tartaric acid and ethylene glycol, and analyzed by means of Auger and photoelectron spectra. It is found that the anodized GaAs films have uniform gallium and arsenic oxide, both at the surface and in the dielectric region, but excess As at the interface between the dielectric region and the semiconductor. For anodized InP films, the interface transition region is relatively narrow, and the excess phosphorus normally found is not observed. (Paper received 10 April 1985.)

REFERENCES

- [1] R. A. Logan, B. Schwartz and W. J. Sundburg, *J. Electrochem. Soc.*, **120**, 1383(1973).
- [2] H. Hasegawa, K. E. Forward and H. Hartnagel, *Electron. Lett.*, **11**, 53(1975).
- [3] B. M. Arora and A. M. Nazele, *Thin Solid Films*, **56**, 153 (1979).
- [4] G. Weimann and W. Schlapp, *Thin Solid Films*, **38**, L5(1976).
- [5] D. L. Lile and D. A. Collins, *Appl. Phys. Lett.*, **28**, 554(1976).
- [6] O. Wada, A. Majerfeld and P. N. Robson, *Solid State Electronics*, **25**, 381(1982).
- [7] C. C. Chang, B. Schwartz and S. P. Muszka, *J. Electrochem. Soc.*, **124**, 922(1977).
- [8] 周勉,王清源,物理学报, **33**, 1485, (1984).
- [9] P. A. Breese and H. L. Hartnagel, *Thin Solid Film*, **56**, 51(1979).
- [10] 周勉,王清源,半导体学报, **5**, 577(1984).
- [11] G. Weimann, *Thin Solid Films*, **56**, 173(1979).
- [12] K. P. Pande and G. G. Roberts, *J. Vac. Sci. Tech.*, **16**, 1470(1979).
- [13] P. A. Breese, H. L. Hartnagel and P. M. A. Sherwood, *J. Electrochem. Soc.*, **127**, 454(1980).
- [14] D. H. Laughlin and C. W. Wilmsen, *Appl. Phys. Lett.*, **37**, 915(1980).

ELECTRON-BEAM RECRYSTALLIZATION OF RF SPUTTERING GaAs SOI AND THERMAL RECRYSTALLIZATION OF MBE GaAs SOI BY RF INDUCTION GRAPHITE STRIP HEATER

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 7 No 3, May 86 pp 327-330

[English abstract of article by Zhu Weiwen [2612 1983 7186], et al., of Shanghai Institute of Metallurgy, Chinese Academy of Sciences]

[Text] The electron-beam recrystallization of RF sputtering GaAs SOI and thermal recrystallization of MBE GaAs SOI by RF induction graphite strip heater are presented for the first time. Using ED, TEM, X-ray diffraction and the Hall effect, the grain size, crystal orientations, carrier concentrations and Hall mobilities of the GaAs films on SOI are measured. (Paper received 28 March 1985.)

REFERENCES

- [1] Y. Akasaka, G. W. Cullen, J. F. Gibbons, C. Hilland and P. J. Vail, *Energy Beam-Solid Interactions and Transient Thermal Processing*, 1983, M. R. S. Symposia Proceedings (North-Holland, New York 1984) p. 3.
- [2] K. K. Ng, G. K. Celler, E. L. Poylonis, L. E. Trimble and S. M. Sze, in ref. 1, p. 599.
- [3] Y. Ohmachi, Y. Shinoda, T. Inai, M. Nakano and M. Takagi, *IEEE Electron Device Letters*, EDL-4, 366 (1983).
- [4] Li Xiqiang, Chen Zhihao, Lin Chenglu and Wang Weiyuan, in ref. [1], p. 621.
- [5] 施若茂, 韩平, 尹金林, 电子学报, 待发表.
- [6] Y. Ohmachi, Y. Shinoda and T. Nishioka, *IEDM Technical Digest* 315 (1983).
- [7] M. Takai, T. Tanigawa, K. Gamo and S. Namba, in ref. [1], p. 397.
- [8] M. Tamura, H. Tamura and T. Tokuyawa, *Jpn. J. Appl. Phys.*, 19, L23 (1980).
- [9] J. C. C. Fan, M. W. Geis and B. Y. Tsaur, *Appl. Phys. Lett.*, 38, 365 (1981).
- [10] R. J. Hawryluk, Andrew M. Hawryluk and Henry I. Smith, *J. Appl. Phys.*, 45, 2551 (1974).

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China Report

SCIENCE AND TECHNOLOGY



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7 AUGUST 1986

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PHYSICAL SCIENCES

EXISTENCE SEEN OF CYCLONIC EDDY IN NORTHERN EAST CHINA SEA

Beijing HAIYANG YU HUZAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 16
No 3, May 1985 pp 240-248

[Article by Zaho Baoren [6392 0202 0088] of Institute of Oceanography at Qingdao, Chinese Academy of Sciences: "Recent Observation Evidence on the Presence of Cyclonic Eddy in the Northern Part of East China Sea"]

[Text] Abstract: This paper briefly summarizes the results of the surveys conducted in the cyclonic eddy zone in northern East China Sea in recent years. Based on the temperature field, mass field and flow field measured in these surveys, cyclonic eddy did exist in the area southwest of Cheju Island during the period. The residual current vector obtained in the survey was plotted with those measured in the past in the same season, resulting in a complete cyclonic eddy flow field. In addition, fundamental characteristics of the Huanghai Sea coastal current in northern East China Sea is also discussed. Our results further confirm that the diagnosis that this cyclonic eddy exists year round and its position is stable is correct.

Based on temperature, salinity and current data gathered in July-August 1972, Hu Dunxin [5170 2415 2946] et al [2,3] pointed out in 1980 that a cyclonic eddy, approximately 60-90 nautical miles in diameter and 40 m in verticle scale, exists southwest of Cheju Island. In 1983, Mao Hanli [3029 3352 4409] et al further confirmed that this cyclonic eddy in northern East China Sea exists year round. In addition, the variation of this eddy in the summer season over the years was discussed based on the temperature field[5,6]. All authors mentioned above believes that the principal reason for the presence of this eddy is due to the horizontal velocity shear of the Huanghai Sea warm current and Huanghai Sea coastal current.

Based on historic data, considerable information on the current north, east and south of the eddy is available. According to the vector diagram thus prepared, the flow field shows a tendency to rotate as a cyclonic eddy. Furthermore, these current vectors are consistent with other currents in the area such as the Taiwan Warm Current, Tsushima Warm Current and Huanghai Sea Warm Current. On

the west side, i.e. the area reached by Hunghai Sea *cold Current and Coastal Current, however, there is relatively little information on the currents in that area. Hence, there are questions and doubts concerning whether there is a cyclonic eddy southwest of Cheju Island. To this end, we conducted three surveys on the hydrologic characteristics of the eddy in recent years. The focus of the measurements was to clarify the currents on the west side of the eddy.

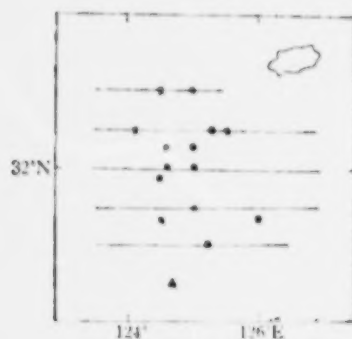


Figure 1. The Survey Area¹⁾

Key:

- buoy; current measuring station in July 1982
- current measuring station in April 1984
- ▲ buoy installed in joint Chinese-American survey in June 1980
- cross-section position

1) A buoy station installed during the joint Chinese-American survey in June 1980 is also included in the figure.

The hydrologic cross-sections and current measuring stations in these three surveys are shown in Figure 1. Based on an analysis, the flow of the Huanghai Sea Cold Current in the northern part of East China Sea was more or less understood. Once again, we proved that there is a cyclonic eddy in northern East China Sea southwest of Cheju Island. These observation results will be briefly discussed in this paper.

*Survey Report No 1154, Institute of Oceanography, Chinese Academy of Sciences. This survey was performed under the guidance of Professor Mao Hanli himself and with the concern of Professor Guan Bingxian [4619 4426 6343]. Many comrades from the technical survey group, hydrolic group and ocean current group participated in these three surveys. Figures in this paper were drawn by Comrade Du Meishan [2629 3270 1472]. The author wishes to express his gratitude to all people mentioned above.

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A. The Three Marine Surveys

1. Results of Observation in July 1980

The survey results centered around buoy arrays deployed in July 1980 were analyzed in detail in references [1,4]. References [5,6] also used some of the results. Hence, only a brief introduction is given here. Figures 2a and 2b show the temperature distribution and dynamic height distribution of the 10 m layer as measured in July 1980, respectively, as well as the average flow velocity vector of the 10 m layer as determined by an anchored array of buoys. In addition, we also included the average velocity vectors of the 14 m and 17 m layers obtained in the Chinese-American joint survey of the mouth of Changjiang River (from early to late June 1980)[7]. Based on Figure 2 we can see that (1) there is a cold center southwest of Cheju Island ($125^{\circ}30'E$, $31^{\circ}N$). The lowest temperature is $19.2^{\circ}C$ which is at least $2.7^{\circ}C$ lower than those measured in surrounding stations. It was also found that the salinity in this cold center is 3.32 percent which is .15 percent higher than those measured in nearby stations. In the dynamic height plot, there is a corresponding closed contour. The Huanghai Sea Warm Current flows by the east and north sides of this contour, as shown in Figure 2 in reference [3], where there is an even higher dynamic height line. Hence, if we set up hydrological stations in this region, there will be more enclosed contours. The geostrophic cold water circulation will be clearer than that shown in Figure 2. (2) Based on the measured flow velocity vectors, the measured flow is very close to the geostrophic flow not only in direction but also in quantity. This fact shows that a geostrophic flow field can be used to approximately express the seawater flow in this region, at least in the summer. (3) As compared to the temperature chart (Figure 2a in this paper and Figure in reference [4]), the direction of the geostrophic current in the middle upper level and that of the measured residual current are in agreement with that of the isothermal lines in the area west of $126^{\circ}E$. There is an overall tendency for the cold current of the Huanghai Sea to move southward. This shows that there is indeed a cyclonic cold eddy in the northern part of the East China Sea southeast of Cheju Island.

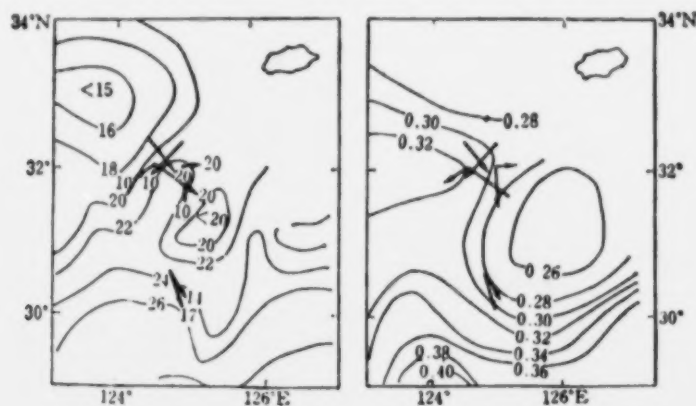


Figure 2. Temperature, Dynamic Height Distribution and Measured Flow Speed at 10 m Depth in July 1980. a. Temperature distribution; b. dynamic height distribution (vectors shows are measured residual currents and values shown near the vectors are water depth levels.)

2. Results of Observation in July 1982

In order to further understand the hydrological structure of this eddy region in the summer and the flow west of this area, the survey vessel "Science 1" conducted a hydrological survey in July 1980. Figures 3a and b are the salinity distributions at 20 m and 35 m levels. Based on Figure 3, on the east side of the area surveyed, a cold center with an enclosed isotherm was found at 20 m. Its temperature is at least 5°C lower and its salinity is at least .05 percent higher than its surrounding environment. The center of this cold water region is located near 31°30'N and 125°45'E. At 35 m depth, this cold center has already shifted northward by about 1 degree latitude to 32°30'N and 126°00'E. In addition, we can also see that there is a warm water tongue north of the cold center extending southwestward. This type of warm water tongue has been found several times before such as in July 1973 and June 1979¹⁾. We believe that this is due to the branching of the Huanghai Warm Current before entering the Huanghai Sea. It is called the west branch of the Huanghai Warm Current. It often partially or completely cuts off the southbound Huanghai Cold Water to create an isolated cold water zone southwest of Cheju Island.

Based on the residual current vectors shown in Figure 3 (Figure 3b shows vectors at 30 m depth), the flow direction is south on the west side of the cold center, which more or less agrees with the temperature distribution. Based on the data shown in Figure 3a on the flow on either side of the warm water tongue, the residual currents at 20 m and 30 m are mostly southwest, approximately agreeing with the axis of the warm water tongue. Furthermore, the residual currents measured at the two most north stations showed eastward flow. Based on the temperature field, this was a sign that the cold water eddy of the Huanghai Sea reached there.

The cross-sectional diagram (Figure 4) shows that the high salinity cold water at the bottom is rising between 125° and 126°30'E. The cold water only reached 20 m level, lower than previous years.

In summary, in July 1982 the cross-sectional diagram clearly shows that cold water is rising. The horizontal chart shows a relatively strong high salinity cold center with an enclosed isotherm. Moreover, a warm water tongue extending southwestward was found on the northwest side of the cold center. Southward residual currents were measured west of the cold center. In addition, the direction of the residual current is more or less in agreement with the temperature field. Based on these facts, the cyclonic eddy did exist southwest of Chenju during this survey.

3. Results of Observation in July 1983

Based on the data gathered in the spring of 1973 (April-May), Mao Hanli^[5,6] et al believed that a cyclonic eddy southwest of Cheju Islands also existed in the spring. As shown in Figure 3 of references [5,6], the residual current

1) Zhao Baoren, Current Structure in Cold Eddy Region in Northern East China Sea, [OCEAN AND LAKES], to be published.

distribution measured in April-May 1973 is located south, east and north of the eddy. There is no data west of the region. For this reason, we conducted another hydrological survey in this area in April 1983. Five ocean current observation stations were set up on the west side in order to gather data regarding the expansion of the Huanghai Cold Current into northern East China Sea in the spring.

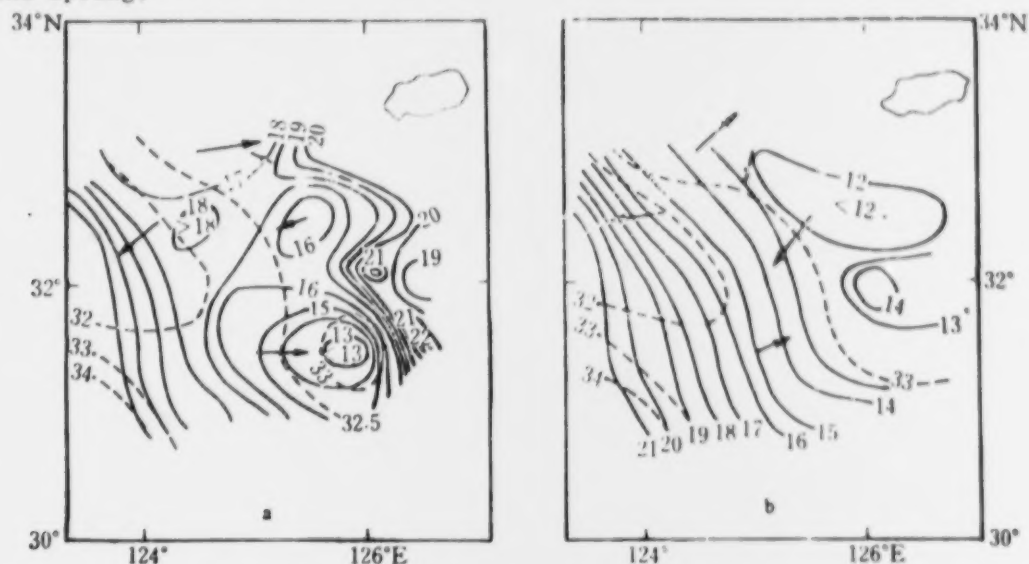


Figure 3. Horizontal Distribution of Temperature, Salinity and Residual Current in July 1982

- a. 20 m depth
- b. 35 m depth

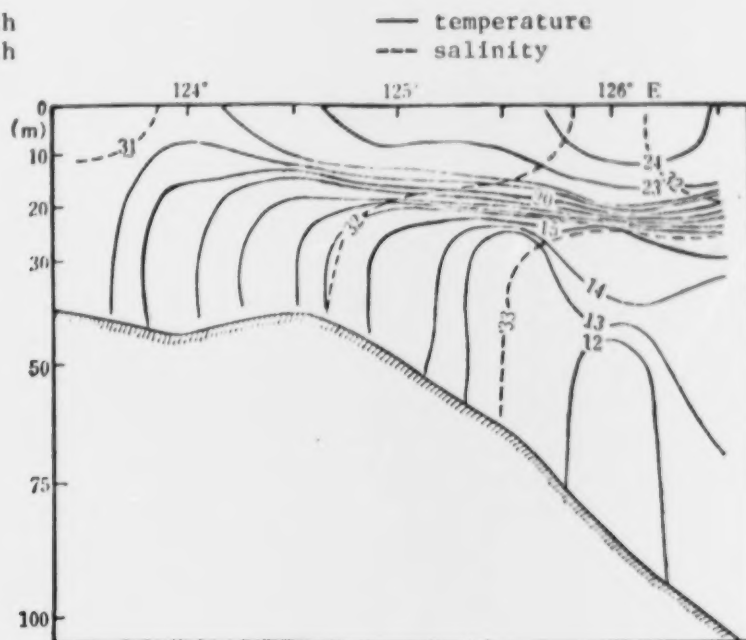


Figure 4. Temperature Cross-section at 32°N in July 1982

- temperature
- salinity

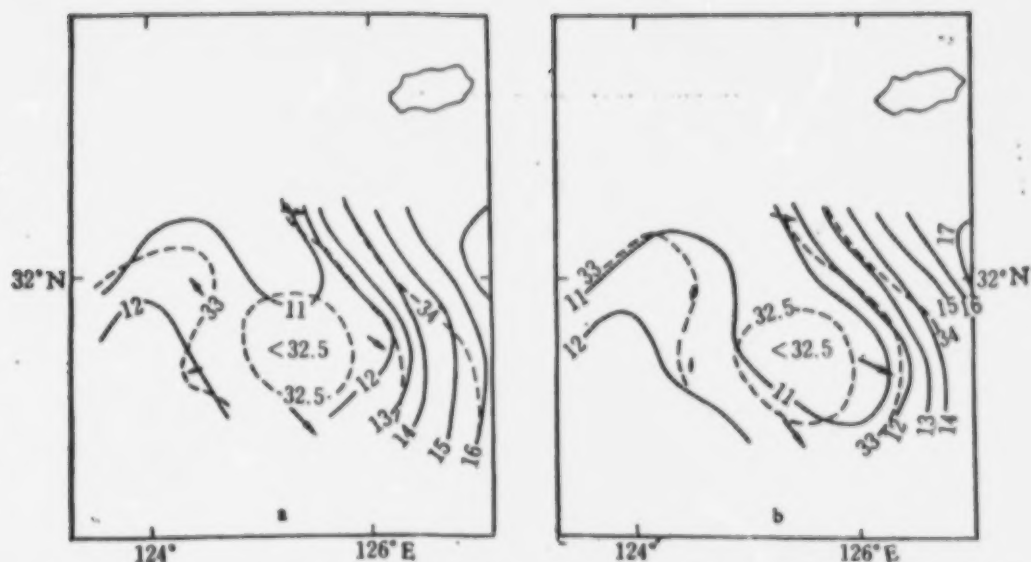


Figure 5. Temperature and Salinity Distribution and Residual Current in April 1983 (same as in Figure 3)

- a. 20 m level
- b. 35 m level

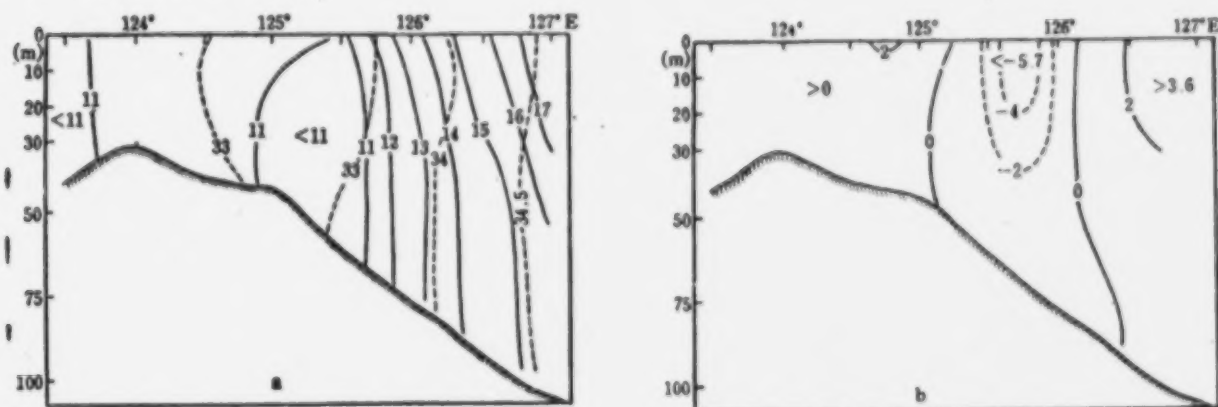


Figure 6. 32°N Cross-section Diagrams Obtained in April 1983

- a. temperature and salinity
- b. geostrophic flow speed

Figures 5a and b show the distributions of temperature, salinity and residual current vector obtained in this survey at 20 m and 30 m. Based on the figure, there is a low temperature, low salinity tongue in the middle of this area extending from NNW toward SSE. This shows the tendency for the low salinity

cold water of the Huanghai Sea to extend into northern East China Sea. On either side of this tongue, two high temperature, high salinity tongues are extending northward. The west one is due to the northward extension of the Taiwan Warm Current and the east one is due to the northwestward extension of the Huanghai Warm Current. From Figure 5 we can see that the two high temperature, high salinity tongues are approaching the cold water tongue north of 32°N . It is more apparent for the Huanghai Warm Current. Due to this effect, the low temperature, low salinity tongue south of 32°N appears as the head of a snake. Although temperature is rising in April, however, lamination effect is not obvious. From surface to bottom, the overall trend for horizontal distribution of temperature and salinity remains the same.

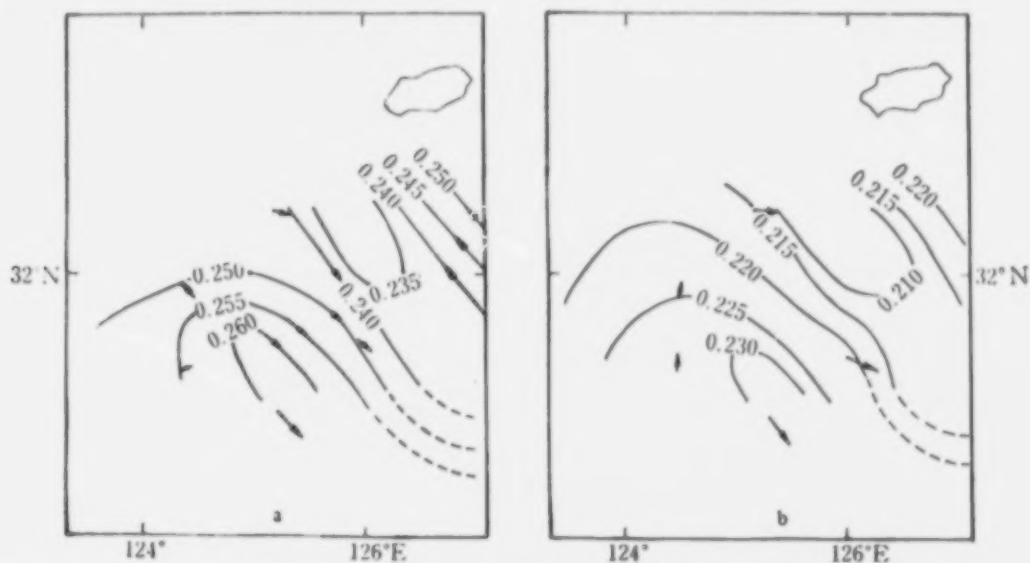


Figure 7. Dynamic Height Obtained in April 1983

- a. 20 m level
- b. 30 m level

The residual current vector obtained in this survey is relatively small, usually not more than 10 cm/s. Its direction is more or less in agreement with the tongue axis of temperature and salinity (see Figure 5). Dynamic calculation shows that the trend for geostrophic current in the cold water region agrees with that of the measured residual current. Based on Figure 6a, a low temperature, low salinity center exists at 125°E – 126°E . This is the bulk of the southward Huanghai Cold Current. From Figure 6b, the geostrophic current calculated to the right of this cold center moves southward and reaches a maximum. The calculated geostrophic currents on both sides are pointing northward. Thus, the geostrophic current pattern agrees with that based on the temperature and salinity tongue distribution. Similar tendency was found along several cross-sections in the south. The difference is that the center of the southward geostrophic current also moves southeastward as the cold center moves in the same direction.

Figure 7 shows the dynamic height obtained in this survey at 20 m and 30 m. Due to lack of data, only a partial elliptical cyclonic circulation is drawn southwest of Cheju. Considering the flow of the Huanghai Warm Current southwest of Cheju in the spring, it is possible to complete the ellipse. Hence, during this survey period the cyclonic eddy also existed.

II. Huanghai Coastal Current in Northern East China Sea

There is a wide range of low salinity cold water in northern East China Sea. As for the important questions such as the dynamic nature of the area, how does it reach northern East China Sea, and how fast does it flow, some fundamental understanding has been obtained based on analyses of the three surveys.

Based on Figure 2, the summer Huanghai Coastal Current flows southeastward with the cold water density circulation in southern Huanghai Sea. When it reaches the 32°N line east of 124°E , it is deflected toward the southeast on the west side of the cyclonic eddy described above. Then, it merges with the Taiwan Warm Current south of 31°N and east of 124°E and then moves toward southeast. Based on residual current vector measured, Huanghai Coastal Current reaches 10-15 m/s after it gets to East China Sea. It mixes with the surrounding seawater continuously. First, it mixes with the warm water carried by the western branch of the Huanghai Warm current near 32°N and then merges with Taiwan warm water further south (south of 31°N). In addition, the upper layer is mixed with the fresh water of the Changjiang River.

As described earlier, cold water is delivered to East China Sea by the spring Huanghai Coastal Current in the direction of the tongue axis (southeast). At this time, the direction of Huanghai Coastal Current is monotonous. It flows consistently southeastward from southern Huanghai to northern East China Sea. Based on the data and dynamic calculation, its flow speed can also reach 10 cm/s in the spring.

Based on a comparison of dynamic calculation and residual current measurement, in spring and summer, the Huanghai Coastal Current is basically geostrophically balanced as it moves south. But, the situation in spring is different from that in the summer. In spring, the temperature difference between the south-bound cold water and the surrounding water is relatively small. Because of its apparent low salinity, although the Huanghai Coastal Current is geostrophic, it moves along the axis of the temperature and salinity tongue. In summer, it moves southward along the west side of the cold center. At this time, the isotherms approximately reflects the geostrophic flow. We do not have any residual current data in fall and winter seasons. However, based on the geostrophic flow, its distribution in winter is more or less similar to those shown in Figures 6 and 7. In the fall, before the end of October, it is approximately the same as that in the summer. Thus, the coastal current in winter is expected to be the same as spring and the situation in the fall is similar to that in summer.

III. Flow Field Measured in Eddy Region

Another important question to be explained is that whether the flow velocity vectors measured on the west side of the eddy agrees with other vectors observed

during the same period in the past. Figures 8 and 9 show the results combining the residual current vectors observed in the summer (solid lines) and those obtained in July-August 1972 (dotted lines). Figures 8a and 9a show the residual current distribution at 10 m and Figures 8b and 9b show that at 20 m. Based on these four figures, the residual current vectors observed in the summer of 1980 and 1982, together with those measured historically in the same period, form a complete cyclonic eddy motion. The center of the eddy is approximately located at 126°E and $31^{\circ}30'\text{N}$. The diameter of the eddy is 2 latitude units. It should be pointed out that this situation not only occurs at 10 m and 20 m. From 5 m to 50 m, similar trend exists.

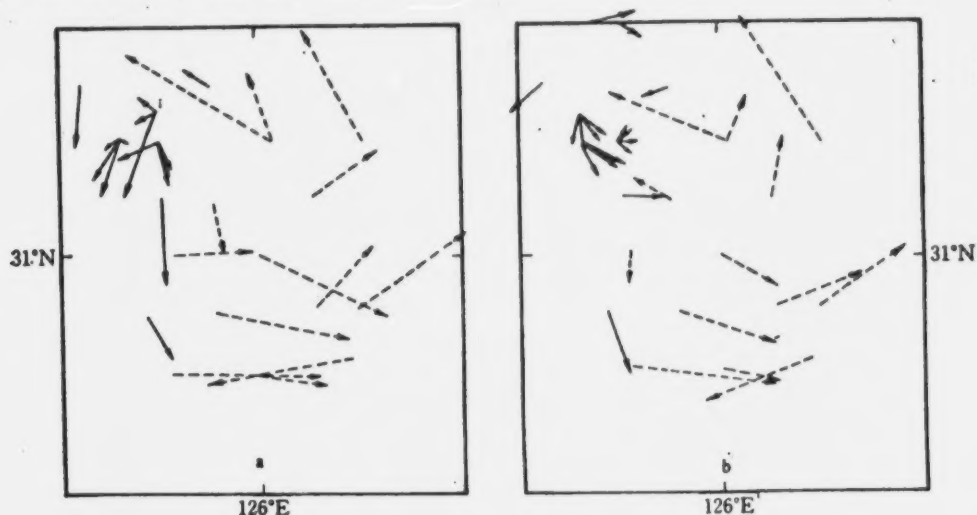


Figure 8. Residual Current Together with Data Obtained in Summer 1972

a. 10 m layer

b. 20 m layer

(Dotted vectors are 1972 summer data.)

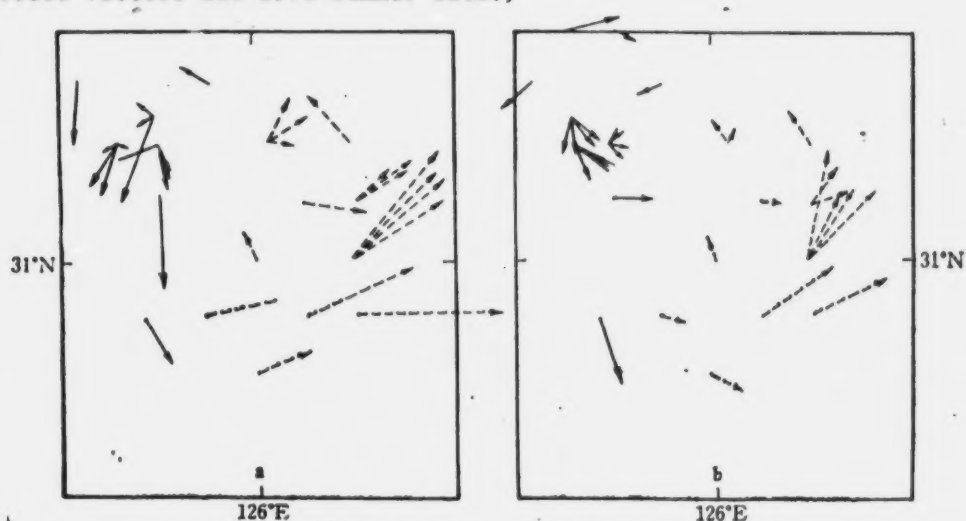


Figure 9. Measured Residual Current Combined with Summer 1973 Data.

a. 10 m layer

b. 20 m layer

(Dotted lines represent 1973 summer data.)

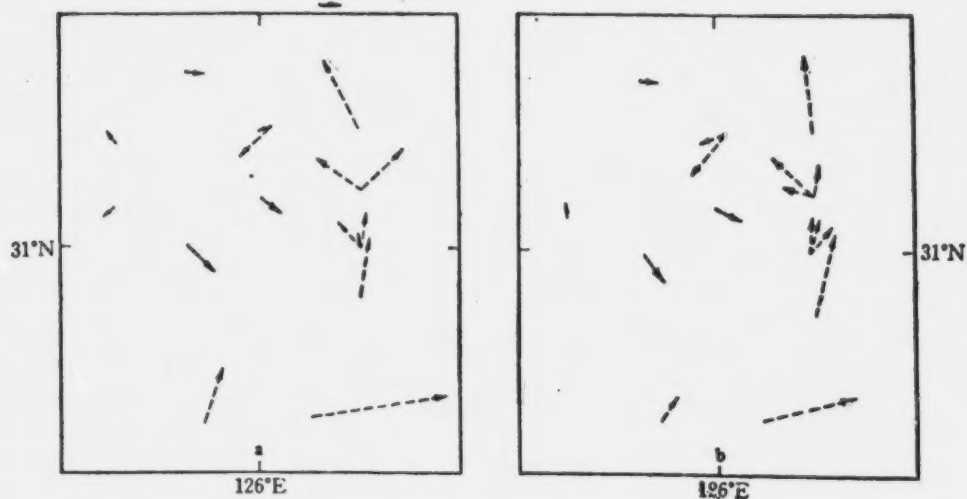


Figure 10. Measured Residual Current Combined with Spring 1973 Data

a. 20 m layer

b. 30 m layer

(Dotted lines represent spring 1973 data.)

Figure 10 shows the combination of the residual currents measured in April 1983 and April-May 1973. Based on the figure, similar to the summer flow field, the combination of flow velocities measured over the years in the spring form a complete cyclonic flow field. The difference is that the spring flow field appears as an ellipse in the north-south direction which is consistent with the distribution curve shown in Figure 7. Furthermore, the center of the eddy is shifted southeastward by a half latitude unit. The spring eddy thickness is over 50 m.

IV. Conclusions

Major findings of hydrological surveys conducted in northern East China Sea have been described above. The flow of Huanghai Coastal Current into northern East China Sea has been explained. We also pointed out that a cyclonic eddy southwest of Cheju Island was present during every survey. By plotting all the historic residual current data together, the result shows a complete cyclonic eddy in that region. This cyclonic eddy motion indeed exists in the region. Consequently, we proved that the conclusion reached by Hu Dunxin [7579 2414 2946] et al^[3] and Mao Hanli et al^[5,6] that a semi-permanent year round cyclonic eddy exists southwest of Cheju Island is correct.

REFERENCES

- [1] Lu Lianghong [0712 5328 3163], 1982, "Analysis of Flow Measurement by Anchored Buoys in Northern East China Sea," HAIYANG KEXUE [OCEANIC SCIENCE] 6: 4-8.

- [2] Hu Dunxin, Ding Zongxin [0002 1350 0207] and Xiong Qingcheng [3574 1987 2052], "Preliminary Analysis on Cyclonic Eddy in Northern East China Sea," 1980; KEXUE TONGBAO [SCIENCE COMMUNICATIONS] 25 (1): 29-31
- [3] Hu Dunxin, Ding Zongxin and Xiong Qingcheng, 1983, "Preliminary Analysis on Cyclonic Eddy Sea in the Summer," HAIYANG KEXUE JIKAN [SYMPOSIUM ON OCEAN SCIENCE] 21: 87-99.
- [4] Xiong Qingcheng and Zhao Baoren, 1984, "Observation and Analysis of Temperature, Salinity and Current in Cold Eddy Region in Northern East China Sea in July 1980," HAIYANG KEXUE [OCEAN SCIENCE] 1: 1-6.
- [5] Mao Hanli, Hu Dunxin, Zhao Baoren and Ding Zhongxin, 1983. "A Cyclonic Eddy in the Northern East China Sea." Proceedings of International Symposium on Sedimentation on the Continental Shelf with Special Reference to the East China Sea, 12-16 April 1983, Hangzhou, China. Ocean Press, pp 280-287.
- [6] Mao Hanli, Hu Dunxin, Zhao Baoren and Ding Zhongxin, 1984. "Mesoscale Eddy Movement in the Northern East China Sea," CHINESE JOURNAL OF OCEANOLOGY AND LIMNOLOGY 1 (3): 237-247.
- [7] Zhao Jinsan, Qiao Ronghen, Dong Ruzhou, Zhang Jialin and Yu Shangjing, 1983. "An Analysis of the Current Condition in the Investigation Area of East China Sea." Proceedings of International Symposium on Sedimentation on the Continental Shelf with Special Reference to the East China Sea, 12-16 April 1983, Hangzhou, China. China Ocean Press, pp 288-301.

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SPECTRAL ANALYSIS OF WAVES IN GULF OF TONKIN DESCRIBED

Beijing NANHAI HAIYANG KEXUE JIKAN [NANHAI STUDIA MARINA SINICA] in Chinese
No 2, Oct 81 pp 79-92

[Article by Wang Wenzhi [3769 2429 6347], Nanhai Oceanography Institute, Chinese Academy of Sciences, "A Preliminary Analysis of the Wave Spectrum in the Gulf of Tonkin during the Passing of a Cold Wave"; paper received 10 October 1978]

[Text] Although lots have been accomplished in the study of sea-wave spectrum, its spectrum form has not yet been unified. The various spectrum representations that have been proposed give the results that are quite different from one another. Therefore, it is extremely important to analyze the observed wave spectra of a selected area of the sea. On the one hand, it will produce knowledge about the composition of the wave spectrum of a certain sea zone, which will be useful for areas such as constructions at sea, ship-building and wave forecast. On the other, it will provide information helpful to the comprehensive efforts in the theoretical study of sea-wave spectrum.

Spectrum calculations were carried out on 12 wave records from a fixed site in the Gulf during the passing of a stormy cold wave and a preliminary analysis and discussions of the results are presented in this article. Among the 12 calculated correlation function graphs, some are not perfect. Either they don't oscillate along the time axis or they are far from approaching zero. These are probably due to insufficient measuring time and the presence of the "zero-line drifting" phenomenon, which will be discussed in this article.

1. Source of Data

The wave data used in this article were measured by a wave gauge on board a Chinese ship at a hydrological station (109°15'E and 20°45'N) in the Gulf of Tonkin between 23:30 of 16 January 1973 and 14:00 of 17 January 1973. For practical reasons, each measurement lasted only about 10 minutes. At the same time waves were measured, wind speed, wind direction, and water level were also recorded. Wind speed was recorded by an automatic anemometer, which records the average wind speed at 2 minute intervals. Table 1 lists the wind speed, wind direction and water level changes recorded during the passing of this storm and Figure 1 shows the changes of wind speed and tide level.

Figure 1. Changes of wind speed and water level at a hydrological station in the Gulf of Tonkin during a storm on 17 January 1973.

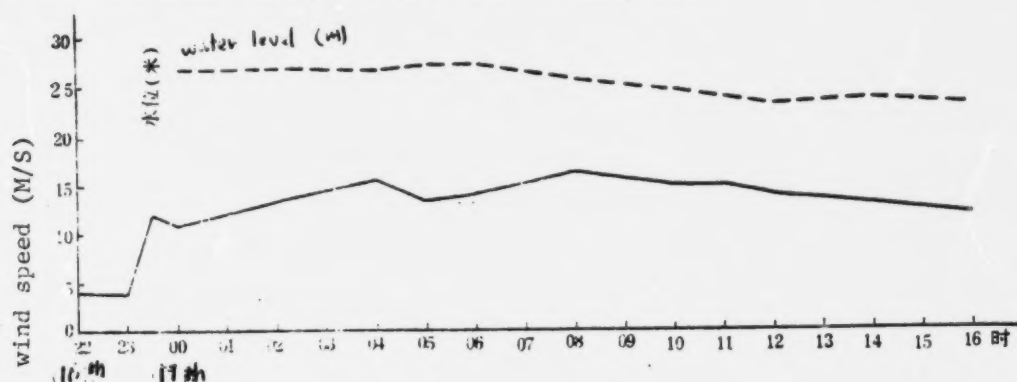


Table 1. Recorded wind and water level data

a 观测时间 (日,时:分)	b 风 速 (米/秒)	c 风 向	d 风区长度 (公里)	e 风区内平均水深 (米)	f 实测水位 (米)
16,23:30	12.0	N	77	20	
16,23:52				20	
17,00:00	11.0	NNE	95	20	26.7
17,02:00	13.5	NNE	95	20	27.0
17,04:00	15.6	NNE	95	20	26.8
17,05:00	13.5	NE		20	27.3
17,06:00	14.0	NNE	95	20	27.3
17,08:00	16.5	NNW		20	25.8
17,09:00				20	
17,11:00	15.0	N	77	20	
17,12:00	14.0	N	77	20	23.0
17,14:00	13.0	N	77	20	23.5

Key:

- a. Observation Time (day, hr:min) d. Fetch length (Km)
 b. Wind speed (m/s) e. Average depth within the fetch (m)
 c. Wind direction f. Measured water level (m)

(Subsequently, the data will be designated by their observation times.)

2. Methods and Results of the Spectrum Calculations

We treated the sequences of wave observed as a quasi-stable process. The continuous wave records were scattered by a time interval of $\Delta t = 0.375$ s to get a series of samples from the time sequence $\{x_i = x(i\Delta t), i = 1, 2, \dots, N\}$. The wave spectra were then calculated in four stages.

(1) Calculations of the average values

$$\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i \quad (1)$$

(2) Calculations of the correlation functions

$$C_\tau = C(\tau \Delta t) = \frac{K^2}{N - \tau} \sum_{i=1}^{N-\tau} (x_i - \bar{x})(x_{i+\tau} - \bar{x})$$

$$\approx \frac{K^2}{N - \tau} \sum_{i=1}^{N-\tau} x_i x_{i+\tau} - K^2 \bar{x}^2$$

$$\tau = 0, 1, 2, \dots, m \quad (2)$$

where K is a factor for the conversion of height on chart paper into actual height.

(3) Calculations of the unrefined wave spectrum

$$V(\omega_h) = \frac{2\Delta t}{\pi} \left[C_0 + 2 \sum_{\tau=1}^{m-1} C_\tau \cos \frac{\pi \tau}{m} h + C_m \cos \pi h \right]$$

in which

$$\omega_h = h \Delta \omega = \frac{\pi}{m \Delta t} h$$

$$h = 0, 1, 2, \dots, m \quad (3)$$

(4) Calculations of the refined wave spectrum

$$S(\omega_0) = 0.54V(\omega_0) + 0.46V(\omega_1)$$

$$S(\omega_h) = 0.54V(\omega_h) + 0.23[V(\omega_{h-1}) + V(\omega_{h+1})]$$

$$h = 1, 2, \dots, m-1$$

$$S(\omega_m) = 0.54V(\omega_m) + 0.46V(\omega_{m-1}) \quad (4)$$

Actual calculations were carried out on a model DJS-21 computer. The data for each time sequence are shown in Table 2. Through the calculations, 12 correlation functions and spectra were obtained, 4 of them are shown together in Figure 2. To make it easier for comparison, we divided the 12 spectra into 2 groups: those before 170800 in one group and those after in the other. They are shown as a group in Figures 3 and 4.

In the program for wave spectrum calculations, we also included the calculations of three relevant features:

(1) Calculations of the zero-, 2nd-, and 4th-order moments of the spectrum, M_0 , M_2 , M_4 , and the spectrum width coefficient ε . The equations are as follows:

$$M_0 = \frac{1}{3} \left(\frac{\pi}{m \Delta t} \right)^1 [1 \cdot S(\omega_0) + 4 \cdot S(\omega_1) + 2 \cdot S(\omega_2) + \dots$$

$$+ 4 \cdot S(\omega_{m-1}) + 1 \cdot S(\omega_m)]$$

$$M_2 = \frac{1}{3} \left(\frac{\pi}{m \Delta t} \right)^3 [1 \cdot 0^2 \cdot S(\omega_0) + 4 \cdot 1^2 \cdot S(\omega_1)$$

$$+ 2 \cdot 2^2 \cdot S(\omega_2) + \dots + 4 \cdot (m-1)^2 \cdot S(\omega_{m-1})$$

$$+ 1 \cdot m^2 \cdot S(\omega_m)]$$

$$M_1 = \frac{1}{3} \left(\frac{\pi}{m \Delta t} \right)^3 [1 \cdot 0^4 \cdot S(\omega_0) + 4 \cdot 1^4 \cdot S(\omega_1) + 2 \cdot 2^4 \cdot S(\omega_2) + \dots + 4 \cdot (m-1)^4 \cdot S(\omega_{m-1}) + 1 \cdot m^4 \cdot S(\omega_m)] \quad (5)$$

$$\varepsilon = \sqrt{1 - \frac{M_1^2}{M_0 M_4}} \quad (6)$$

The calculated values of M_0, M_2, M_4 , and are listed in Table 3. The calculated M_0 should equal to $2C_0$.

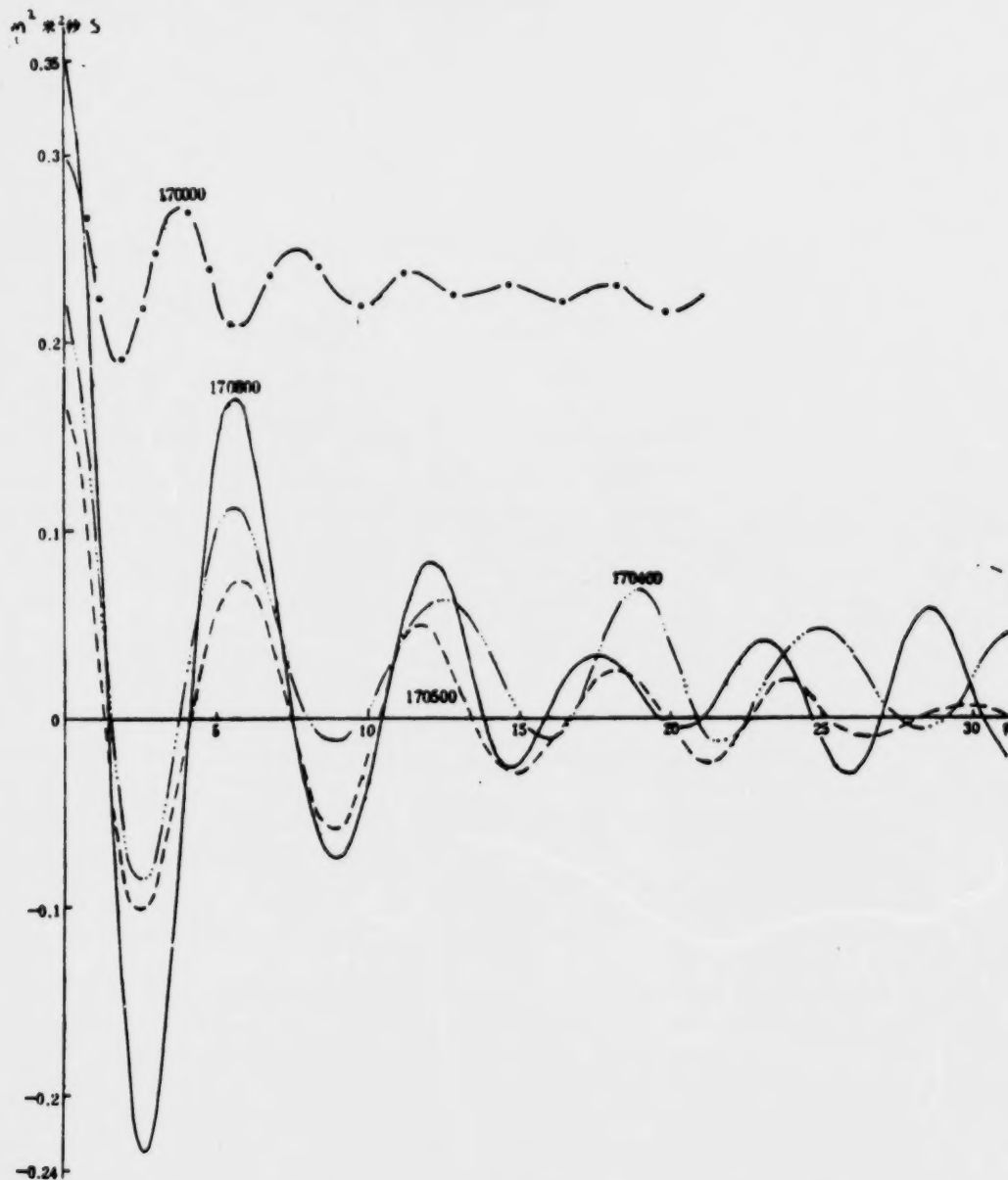


Figure 2. The correlation functions of four sets of records.

Table 2. Related parameters in the spectral analysis of the recorded data.

编号 No.	(s) Δt (秒)	N	(min) T (分)	# of wave 波的不数	m	df
162330	0.375	1124	7.0		42	53
162352	0.375	1440	9.0		56	51
170000	0.375	1468	9.2	145	56	51
170200	0.375	2048	12.8	153	84	48
170400	0.375	2048	12.8	154	84	48
170500	0.375	2048	12.8	150	84	48
170600	0.375	1440	9.0	100	56	51
170800	0.375	2048	12.8	154	84	48
170900	0.375	1500	9.4	109	56	53
171100	0.375	2048	12.8	147	84	48
171200	0.375	1512	9.5	110	56	54
171400	0.375	2048	12.8	151	84	48

t--time interval; N--sample capacity of a time sequence; T = N t--total duration of a time sequence; m--# of data point for correlation function and spectrum; df = 2[N/m-1/2]--degree of freedom of the calculated values. Values of 50-60 are appropriate for wave spectrum analysis.

Table 3. Calculated values of moment and spectrum width coefficient.

编号 No.	M_0 (米 ²) (m ²)	M_2 (m ² S ²) (米 ² 秒 ⁻²)	M_4 (m ⁴ S ⁻⁴) (米 ⁴ 秒 ⁻⁴)	s
162330	0.026	0.240	7.408	0.834
162352	0.106	0.356	4.014	0.837
170000	0.592	0.430	3.490	0.954
170200	0.278	0.578	3.852	0.829
170400	0.430	0.840	9.826	0.912
170500	0.328	0.688	4.946	0.841
170600	0.512	0.888	4.788	0.823
170800	0.702	1.240	9.964	0.883
170900	0.588	0.972	5.394	0.838
171100	0.292	0.578	4.862	0.875
171200	0.428	0.854	8.750	0.897
171400	0.360	0.870	11.006	0.900

(2) Examining the changes of the correlation functions. Given $\delta > 0$ and a positive integer δ_m , a number m is selected by computer such that the absolute values of the final δ_m correlation function values C_j do not exceed δ , that is

$$|C_j| \leq \delta \quad j = m - \delta_m + 1, m - \delta_m + 2, \dots, m$$

Figure 3. The Spectra of 162330-170800.

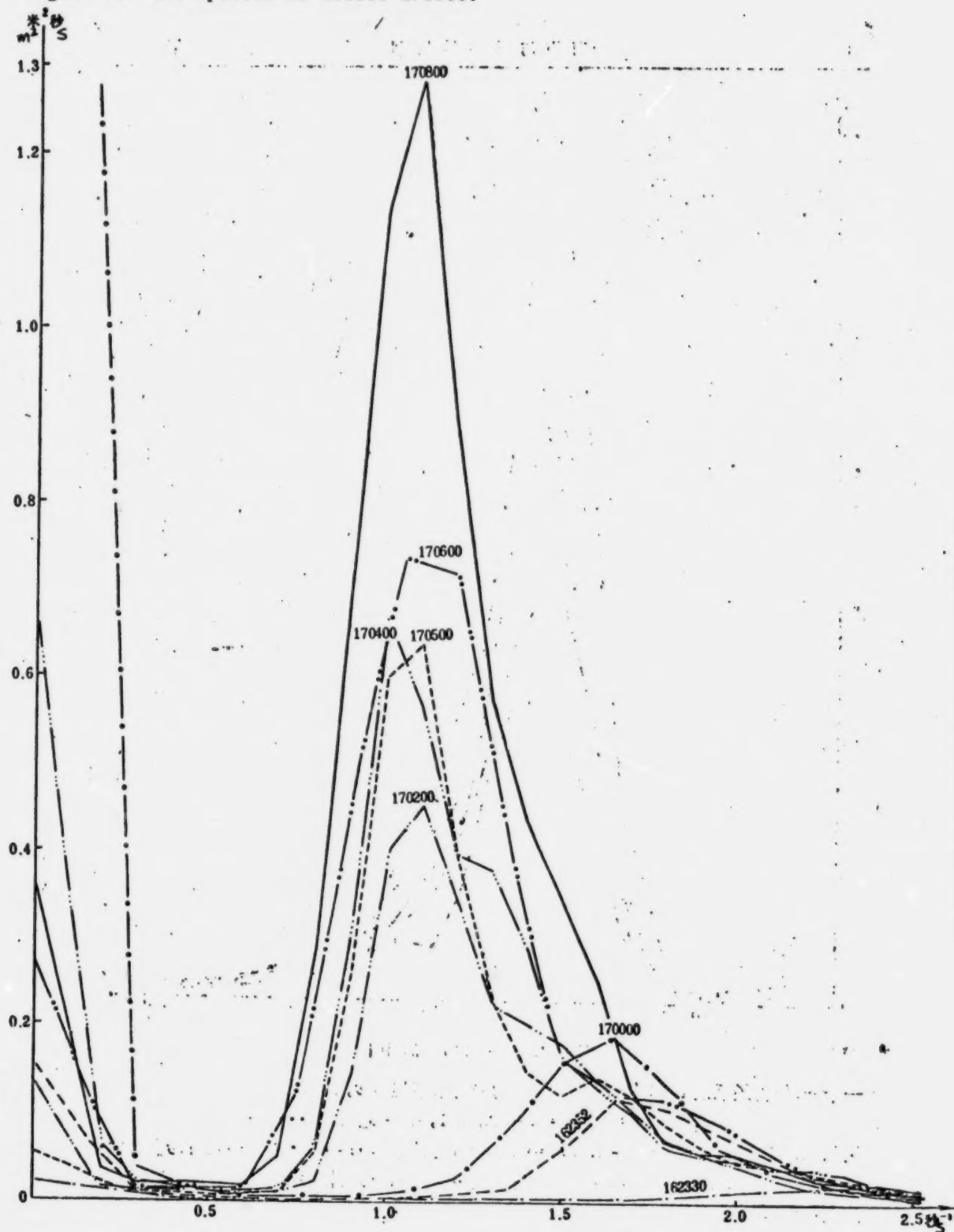
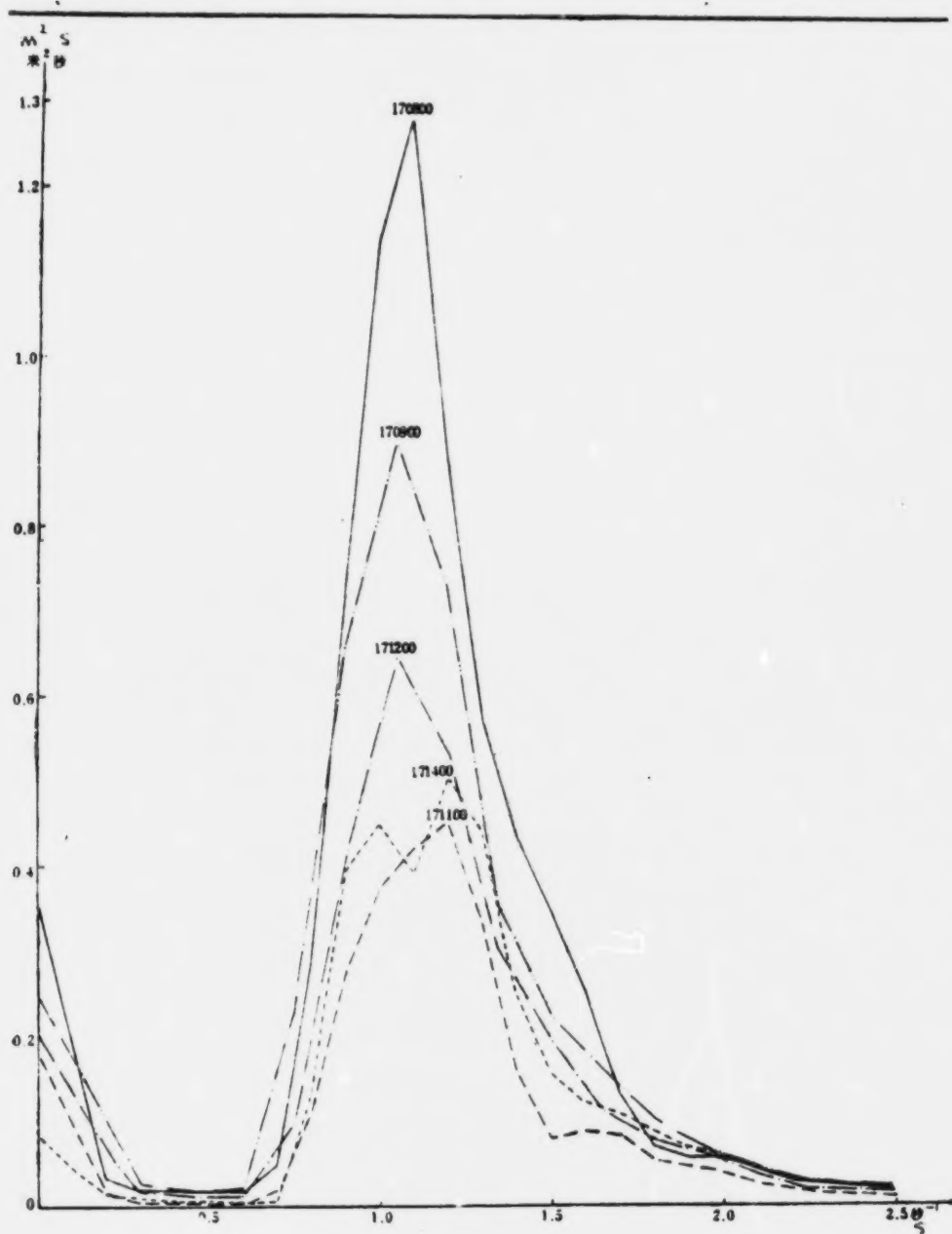


Figure 4. The spectra of 107800-171400.



Take 170800 as an example. When $\delta = 0.1$ and $\delta m = 20$, the result is $m = 38$; When $\delta = 0.01$ and $\delta m = 20$, it is $m > 222$. It is clear that even with a very large m the oscillation amplitude of the correlation functions is not completely reaching zero.

(3) Dividing each time sequence into four sections and calculating their averages. Given the averages of the four sections, comparisons of them with the total average of the time sequence can be made. We define the maximum deviation of the section averages from the total average as

$$\bar{\Delta} = \frac{\max\{|x_i - \bar{x}|\}}{\bar{x}} \quad i = 1, 2, 3, 4 \quad (7)$$

From the values of the maximum deviation we can determine whether the average values of a time sequence are constant or near constant, which would lend support to our treating the sequences of wave as a stable process. Of course, this is not the only criterium. To be a stable process, the condition that "correlation function is related only with time interval" has to be satisfied also. We did not check if this condition was met.

The $\bar{\Delta}$ values for the 12 time sequences are listed in Table 4. Except for 170000, the $\bar{\Delta}$ values of all sequences lie between 0.8-6.7 percent. The deviations are very small. This provides some ground in our treating approximately the sequences of wave as a stable process.

Table 4. Maximum deviations of section averages from the total average.

编 No. 号	$\bar{\Delta}$ (%)	编 No. 号	$\bar{\Delta}$ (%)
162330	2.1	170600	5.4
162332	3.3	170800	4.4
170000	31.7	170900	3.9
170200	4.0	171100	3.2
170400	6.7	171200	5.5
170500	0.8	171400	1.4

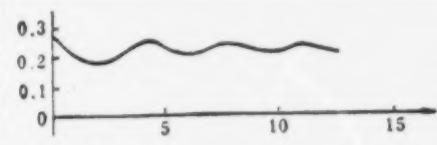
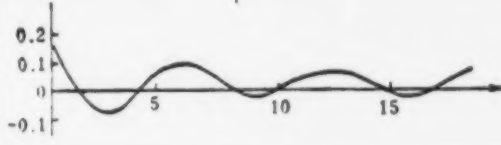
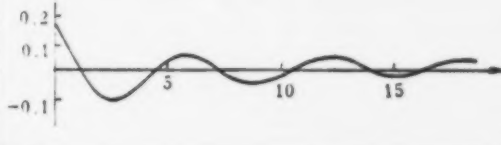
3. Analysis and Discussions of the Results

From their appearances, our graphs show only the energy distributions of the component waves within a frequency range and particularly that their peaks all fall within a narrow frequency range. It can be seen from Figure 3 that the curves become steeper as wind speed, wind duration and fetch increase and the total area under the curve also increases. Also the spectral peaks span a wider frequency range and the corresponding wave height and period of the wind-wave increase accordingly. Meanwhile, during the over 2 hours period between 162330 and 170200, the peaks shift rapidly toward low frequency end so the spectra look quite different at low frequency region but very similar at high frequency region. But the phenomenon becomes insignificant after 170200. Though the peaks still shift toward low frequency end, it happens at a far slower speed. Not only the curves are very similar, but the maxima of

the spectra occur at nearly the same frequency. The values of later-stage spectra are generally greater, at all frequencies, than the corresponding ones of early-stage spectra. It can be seen from Figure 4 that the peaks diminish and the areas under them decrease as wind speed and fetch decrease. But the frequency range of these peaks changes very little and the decrease of the corresponding wave height is more noticeable than that of the period.

There is a common feature in this two groups of spectral graphs, namely the spectrum values do not approach zero at the very low frequency end of these spectra (near $\omega = 0$). This is physically impossible. To certain extent, this phenomenon can be attributed to calculation errors. And these errors have to do with the errors introduced in our determination of the zero-line of a wave profile. In other words, the time sequences are not completely centered. In the spectral analysis of these wave data, we simply used the total averages of the time sequences and that is not good enough. Due to the effect of tidal fluctuations, the effect of "zero-line drifting" in the recorded data, or other errors in calculation, the time sequences are not completely centered. The hint and extent that the 12 sets of the data analyzed are not completely centered can be seen from their $\bar{\Delta}$ values, correlation function graphs and spectra. Three key data are listed in Table 5. It reveals that the spectrum value at $\omega = 0$ (i.e. the nondimensional quantity $S(0)M_0T$ in table 5) is not associated with wave strength but is dependent on the $\bar{\Delta}$ value and the position of the correlation function curve. To be specific, the greater the and the farther the correlation function curve is away from the time axis, the greater the spectrum value at $\omega = 0$ and the worse it is off the center.

Table 5. The effect of off-center on the correlation function graph and spectrum.

No. 编 号	$\bar{\Delta}$ (%)	Correlation Function Graph 相 关 函 数 图 形	$\frac{S(0)}{M_0 T} \times 10^{-1}$
170000	31.7		10.3
170400	6.7		2.0
170500	0.8		0.2

When we selected the scattered data points x_i from the record, we assumed the zero-line of the measured curve was a straight line and the readings were made based on a line parallel to the assumed zero-line (such as baseline I in Figure 5). When the zero-line of the measured curve drifts (line the curve in Figure 5), then it is unlikely to be completely centered. If we re-examine the circumstances under which the curves were measured and draw as closely as possible the actual zero-line (not necessarily a straight line), and then select a baseline II that is parallel to it (as shown in Figure 5) for data readings, the extent that the time sequences are centered can be greatly improved. We purposefully applied the method on 170000 and 170400, which have the largest zero-line drifting, to modify the data and carried out similar calculations. The results are shown in Figure 6 and Table 6. When compared with the graphs of 170000 and 170400 in Figures 2, 3 and Table 5, it is obvious that there is a great improvement. In the part that $\omega > 0.5$, the spectral density graphs almost completely coincide with each other. Also for the part that $\omega < 0.5$, particularly near where $\omega = 0$, the spectral density values are very close to zero. The same for the correlation functions. Their graphs agree totally with each other and they oscillate around the time axis and are more symmetrical. In short, they are closer to reality.

Figure 5. Schematic plot of baseline I and II.

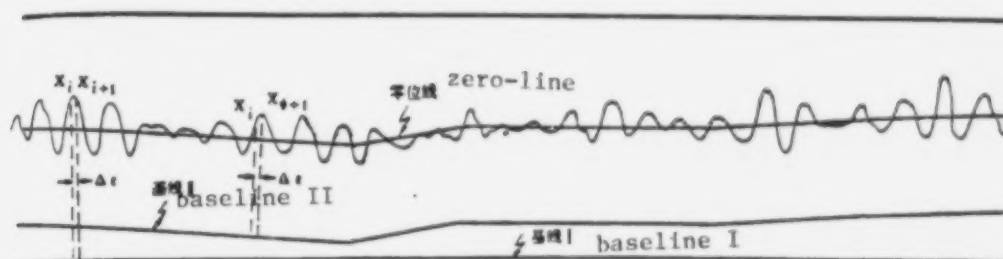


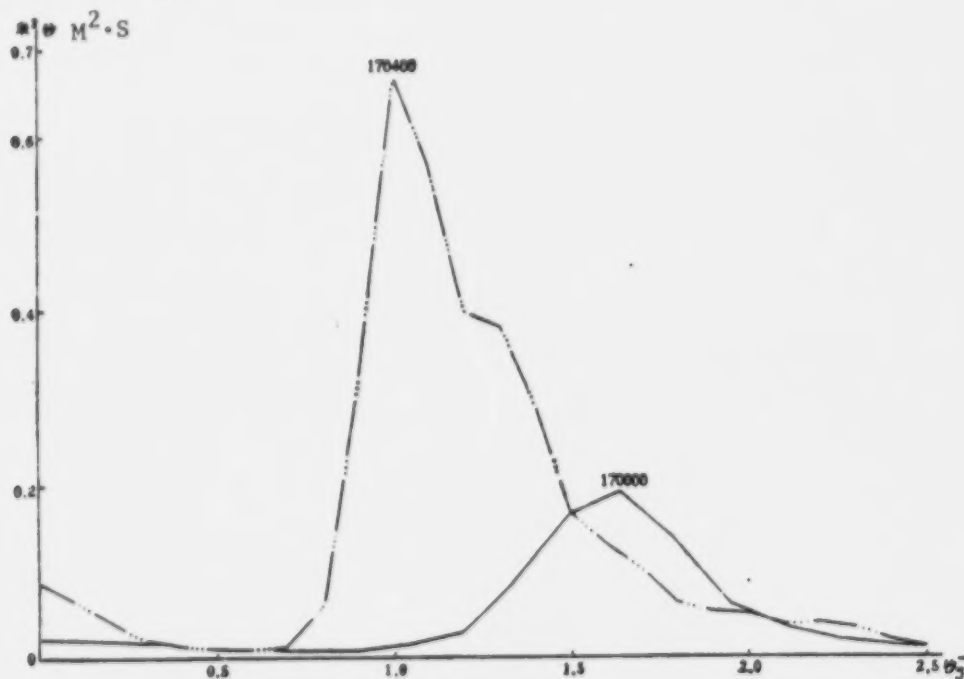
Table 6. The improvements in correlation function graphs and spectra after the degree of centering is improved.

编号 No.	Δ (%)	Correlation Function Graph 相关函数图形	$\frac{S(0)}{M_0^2} \times 10^{-3}$
170000	0.6		0.3
170400	1.4		0.3

Figure 6-a. The calculated correlation function graphs of 170000 and 170400 using the data based on baseline II.



Figure 6-b. The calculated spectra of 170000 and 170400 using the data based on baseline II.

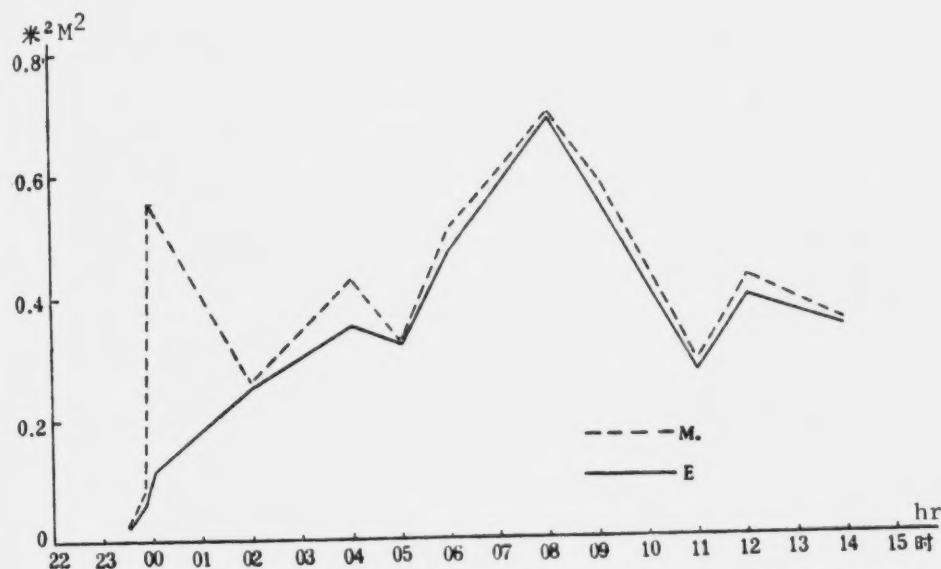


In order to accurately estimate the total area of the spectral peaks (equivalent to the total energy of the wind-wave), we extracted ΔM_0 , the area corresponding to the region of $0 \leq \omega \leq 0.25 \text{ s}^{-1}$, from the total area M_0 to get the modified total area E of the spectral peaks. The results are listed in table 7. Figure 7 depicts the changes of the total area based on the data in table 7.

Table 7. The calculated areas of the spectral peaks.

No. 号	$M_0 (M^2)$ (米 ²)	ΔM_0 (米 ²)(M ²)	$(M^2)E$ (米 ²)	编 No 号	$(M^2)M_0$ (米 ²)	$(M^2)\Delta M_0$ (米 ²)	E (米 ²)(M ²)
162330	0.026	0.0042	0.022	170600	0.512	0.0398	0.472
162352	0.106	0.0224	0.084	170800	0.702	0.0040	0.698
170000	0.592	0.4734	0.119	170900	0.588	0.0398	0.548
170200	0.278	0.0146	0.263	171100	0.292	0.0202	0.272
170400	0.430	0.0738	0.356	171200	0.428	0.0308	0.397
170500	0.328	0.0080	0.320	171400	0.360	0.0102	0.350

Figure 7. Changes in spectral peak areas.



We have mentioned earlier that, as shown in Figure 3, the frequency range that covers the peak and major energy distributions of the wind-wave spectrum shifts from high toward low frequency end. But after 170200, the change becomes less obvious. The major distributions of energy are concentrated within the frequency range of $[0.65, 1.75]$. Table 8 lists the exact values of $[S(\omega)]_{\max}$ of the individual spectrum before 170800, which reach the maximum near the frequency ω_m . The frequency ranges that cover the major distributions of energy are also listed.

The last column in Table 3 were calculated from eq.(6). This is one way to obtain the spectrum width coefficient ξ from the internal structures of the wave. One can also get ξ from the shape of the measured curves for comparison.

Table 8. The distribution characteristics of the wind-wave energy with respect to frequency

编 a 号	$[S(\omega)]_{\max}$ (米 ² ·秒) (M ² , S)	ω_M (S ⁻¹)(秒 ⁻¹)	主要能量集中的频率范围 b	
			频率范围(秒 ⁻¹) c	占总能量的百分比 d
162330	0.018	2.20	[0.8, 5.8]	85
162352	0.120	1.70	[1.35, 2.55]	86
170000	0.190	1.63	[1.35, 2.10]	85
170200	0.468	1.05	[0.65, 1.75]	85
170400	0.676	1.01	[0.65, 1.75]	85
170500	0.664	1.06	[0.65, 1.75]	85
170600	0.796	1.11	[0.65, 1.75]	85
170800	1.300	1.07	[0.65, 1.75]	85

Key:

- a. No
- b. Frequency range that covers the major distribution of energy
- c. Frequency range (s⁻¹)
- d. Percentage of the total energy

If one defines the average period of the measured curve $x(t)$ as $T_r = t'/N_r$, and the average period of $dx(t)/dt$ as $T_c = T'/N_c$ where t' is the time duration of $x(t)$, N_r is the number of times that $x(t)$ reaches zero within time t' and N_c is the number of peaks (the maxima of $x(t)$ values) within the t' , it can be proved that $T_c/T_r)^2 = M_2^2/M_0M_4$. Therefore, eq.(6) can be rewritten as

$$\xi = \sqrt{1 - \left(\frac{T_c}{T_r}\right)^2}$$

or

$$\xi = \sqrt{1 - \left(\frac{N_r}{N_c}\right)^2} \quad (8)$$

The ξ values listed in table 9 were calculated from eq.(8).

It is known that ξ is a distinctive quantity depicting the degree the wind-wave energy is concentrated with respect to frequency and that $0 < \xi < 1$. When ξ is closer to 0, the frequency range in which the spectrum densities converge becomes narrower. In the literature [3], those with $\xi < 0.4$ were referred to as narrow spectrum and those with $\xi > 0.4$ wide spectrum. As evident from Tables 3 and 9, our calculations show that the results from eqs.(6) and (8) are quite different, although these equations are theoretically identical. Generally, the calculations of moment involved in eq.(6) are inaccurate, particularly for higher order moments M_2 and M_4 . Therefore, the calculation results of eq.(8) seem more reliable.

Table 9. The calculated values based on the shape feature of the measured curves.

编 No 号	N_1	N_2	δ
162330	131	147	0.454
162352	147	166	0.465
170000	148	157	0.334
170200	176	204	0.506
170400	180	196	0.396
170500	191	205	0.363
170600	120	131	0.401
170800	172	193	0.454
170900	103	116	0.460
171100	155	175	0.464
171200	119	136	0.484
171400	167	190	0.477

The spectrum is a function of such wave elements as wave height and average period. For example,

$$\bar{H} = 1.77 \sqrt{E}, \quad \bar{H}_1 = 2.83 \sqrt{E}$$

$$\bar{H}_2 = 3.60 \sqrt{E} \quad (9)$$

$$\bar{\tau} = 2\pi \sqrt{\frac{M_0}{M_2}} \quad (10)$$

Table 10 gives the comparison of the measured values of wave height and period with those calculated from eqs. (9) and (10), in which the "measured values" were obtained by statistical means from the measured curves. It can be seen that the measured and calculated wave heights agree well while the calculated periods are significantly lower than the observed, which is probably due to the larger errors in the second-order moment M_2 .

Table 10. Comparison of the calculated and observed values of wave height and period.

编 号 N_0	E (米 ²) (米 ²)	$\sqrt{E}$ (米) (米)	$\bar{H}$ (米)		$H_{1/2}$ (米)		$H_{1/10}$ (米)		$\bar{\tau}$ (秒)			
			$\bar{H}_{1/2}$	$\bar{H}_{1/10}$	$H_{1/2}$	$H_{1/10}$	$H_{1/2}$	$H_{1/10}$	M_0 (米 ²)	M_2 (米 ²)	$\bar{\tau}_{calc}$	$\bar{\tau}_{obs}$
162330	0.022	0.148	0.26		0.42		0.54		0.026	0.240	2.6	
162352	0.084	0.289	0.51		0.82		1.05		0.106	0.356	3.4	
170000	0.119	0.343	0.61	0.59	0.97	0.97	1.24	1.31	0.592	0.430	7.4	3.7
170200	0.263	0.512	0.91	0.97	1.45	1.48	1.85	1.99	0.278	0.578	4.4	5.0
170400	0.356	0.595	1.06	1.08	1.69	1.65	2.15	2.15	0.430	0.840	4.5	5.0
170500	0.320	0.564	1.00	1.06	1.60	1.64	2.04	2.17	0.328	0.688	4.3	5.1
170600	0.472	0.685	1.22	1.30	1.94	2.01	2.48	2.52	0.512	0.888	4.8	5.4
170800	0.698	0.833	1.48	1.30	2.36	2.30	3.01	2.90	0.702	1.240	4.7	5.0
170900	0.548	0.739	1.31	1.30	2.10	2.06	2.67	2.60	0.588	0.972	4.9	5.2
171100	0.272	0.520	0.92	0.98	1.48	1.57	1.88	1.99	0.292	0.578	4.5	5.2
171200	0.397	0.629	1.12	1.14	1.78	1.84	2.27	2.31	0.428	0.854	4.4	5.2
171400	0.350	0.589	1.05	1.04	1.67	1.65	2.13	2.22	0.360	0.870	4.0	5.1

4. Conclusions

The spectral analysis of 12 sets of observed wind-wave data during the passing of a storm was carried out and certain insights about the wind-wave spectrum of the Gulf of Tonkin during the passing of a cold wave were gained. However, some of the information needs to be verified with additional observations. As to the collected wave data, we have to further improve the aspect of data treatment and further refine our analysis methods. First, zero-line drifting exists to a varying extent in the observed wave data. In our attempts to eliminate this effect, we should try various approaches and compare their results; secondly, lots of personal judgment were involved in our selections of m values in eqs.(2), (3) and (4). Different m values will give different spectra. The greater the m , the sharper the spectrum peak. So which m value will give a corresponding spectrum that matches the real spectrum? Thirdly, regarding the problem that the two spectrum width coefficients as calculated from the internal structure and external characteristics of the wind-wave are different, how can they be unified on the basis of their formulas and the physical meaning of ξ ? Fourthly, the data collecting during the passing of the storm was rather thorough. We ought to investigate further the relationship of the spectrum change with wind speed, wind duration, etc. In summary, the analysis of these wave data has to be continued.

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REFERENCES

- [1] Wen Shengchang, "Wave Theory," Shangdong People Press, 1964.
- [2] Blackman, R.B. and J.W. Tukey, 1959, "The Measurement of Power Spectrum from the Point of View of Communications Engineering," New York, Dover.

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PHYSICAL SCIENCES

PHYSICAL, MECHANICAL EFFECT OF VELOCITY OF SOUND IN OCEAN SEDIMENTS

Beijing HAIYANG XUEBAO [ACTA OCEANOLOGICA SINICA] in Chinese Vol 7, No 1, 15 Jan 85 pp 111-119

[Article by Liang Yuanbo [2733 0337 0590] and Lu Bo [4151 0590] of the Chinese Academy of Sciences, South China Sea Institute of Oceanography, Guangzhou; paper received 12 October 1982, finalized 4 April 1983]

[Text] Abstract: The use of acoustical methods to obtain information on the physical-mechanical properties of the ocean floor sedimentary layer has been one of the fast developing ocean floor research methods^[1-4] in recent years. Observations during the last 10 to 20 years using electron microscope technology have led to the discovery of a few important microscopic characteristics of sedimentation; for example, the condition of granular sediment buildup, the pore structure, and aspect ratio of pores, etc. All these have effects which cannot be overlooked when considering the propagation characteristics of sound in ocean floor sediments, particularly in terms of the velocity of sound. In order to clarify the structure of ocean floor sedimentation and the physical mechanism of the mechanical factors that influence the propagation characteristics of sound, the authors investigated the relationship between the microscopic structure of sediment and macroscopic acoustical phenomena. Also, taking one representative area of the continental shelf in the northwest section of the South China Sea as an example, regression analysis was carried out on a set of test data from 17 test sites. Letting the unidimensional compressive strength, q_u , be equivalent to a factor which comprehensively expresses the macroscopic effect of the granular buildup and pore structure of ocean floor sediment, the porosity, n , was used to calculate a supplementary revised term for the speed of sound, c , in the sediment layer. The following empirical formula was obtained:

$$f(c, n, q_u) = c - 4195 + 90.5833n - 0.7895n^2 + 94.6968q_u - 64.4803q_u^2 = 0,$$

The formula raises the calculation precision of the often used formulae (for example, the Anderson formula^[5]) which do not consider pore structure; and, at the same time, it eliminates the necessity of carrying out a statistical survey of corrected sound velocity calculations on microscopic pores.

I. Theory and Present Problems

Experimental results and theoretical analysis point out that, when sound waves passing through a type of fluid such as ocean floor sediment become oversaturated in the medium contained in the pores, their propagation velocity should be influenced by the fluid portion and the solid portion of the medium. M.A. Biot, in a series of papers[6], proposed a theory for sound propagation in oversaturated pore-contained fluids. This theory was also the first to point out the second power relationship of the speed (i.e. sound velocity, c):

$$c^2 = (P + 2Q + R) / \rho, \quad (1)$$

where P, Q and R are the Biot coefficients, namely:

$$P = \frac{(n-1)^2 C_t + (n-1)C_{sp} + C_w}{C_t(C_w - C_{sp}) + C_t C_{sp}} + 4/3\mu,$$

$$Q = -n \frac{(n-1)C_t + C_{sp}}{C_t(C_w - C_{sp}) + C_t C_{sp}},$$

$$R = \frac{nC_t}{C_t(C_w - C_{sp}) + C_t C_{sp}},$$

in which, C_t is the volume compression coefficient of the total sedimentary framework; C_{sp} is the solid granular compression coefficient; C_p is the pore compression coefficient; C_w is the fluid compression coefficient; n is the porosity; and $C_t = nC_p + C_{sp}$.

Although Biot's considerations may be all-encompassing in theory, in practical application these coefficients have almost no possibilities for total measurement. Empirical results also indicate clearly that it is not necessary to measure all these coefficients. For this reason, the simple M.R. Wyllie model and the "Wyllie sound time averaging formula" for porosity in oil bearing sediment and sound velocity related calculations are generally adopted as a basis.

An example of Wyllie's sound time calculation model is shown in Figure 1. It indicates the two substances (a solid consisting granular solids and a liquid or gaseous material consisting of fluid saturated with granular particles) composing the porous media. The propagation velocity of longitudinal waves is equivalent to the velocity through the two types of media according to their volumes when totally separated. Therefore, the sound time, $t = 1/c$ ¹⁾, in passing through the composite medium should equal the sound time of passing through the solid portion plus the sound time of passing through the fluid portion:

$$t = (t_f - t_{ma})n + t_{ma} \quad (2)$$

1) l has a unit of length, dimension: L.

in which, t_f is the value of the sound time in the fluid within the sediment pores and t_{ma} is the value in the solid framework of the sediment.

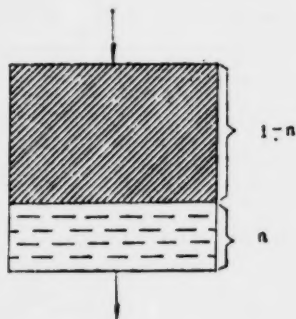


Figure 1. Fundamentals of the Wyllie sound time averaging formula model; the slanted line portion denotes the solid medium, the remainder is the fluid medium; arrowheads indicate the direction of sound wave propagation.

From this, we obtain the relationship between the sediment porosity, n , and the sound velocity, c :

$$c = \frac{1}{n(c_{ss} - c_f) + c_f} (c_{ss} \cdot c_f), \quad (3)$$

where the subscripts of c are the same as in Equation (2).

These concepts have found extensive application over the last 20 years in areas of petroleum geology and acoustical well logging; moreover, they have become the theoretical basis for applied formulae for sound velocity/porosity calculations often used in sediment acoustics (for example, the Anderson formula[5] and formulae quoted in other papers[2,8]).

But, the Wyllie model and its resulting relationships also fail to take into account the natural condition of the pattern of buildup of granular sediment and the state of mechanical coupling. They especially do not consider the form of the sediment porosity and the influence of the dominant orientation of the porosity. Generally speaking, the form of the sediment porosity is a random distribution, but in view of all existing primary and secondary structures like microstrata, microcrevices, spaces between layers, or conditions of statistically dominant orientation of pores of long axis (Figure 2), there appears to be a relatively large discrepancy between the value of sound velocity as derived from the Wyllie formula and that from actual measurements. Biot's theoretical model and Equation (1) have problems similar to these. Because of this, in 1976, M. Nafi Toksoz et al. furthered the investigation into these problems. In calculations based on porous media of equivalent elasticity constant, they showed evidence of porous media of non-spherical pores with different aspect ratios. The velocity of longitudinal and transverse waves showed very great differences as compared to porous media of near spherical pores; among the differences, the effect of

longitudinal waves were greater than that of the transverse waves[9]. Because of this, they proposed the concept of a pore shape chart and also proposed the necessity of determining the aspect ratio of pores, α , to carry out corrections on sound velocity calculations. Wei Moan [7614 1075 4152] and Zhu Zhengya [2612 2973 0068]^[10] furthered the advances by obtaining a pore structure factor, K , on the basis of the determination and analytical calculation of actual microscopic patterns of pores. This describes, in the longitudinal wave direction, the effect of pore shape and effective pore diameter on sound velocity.

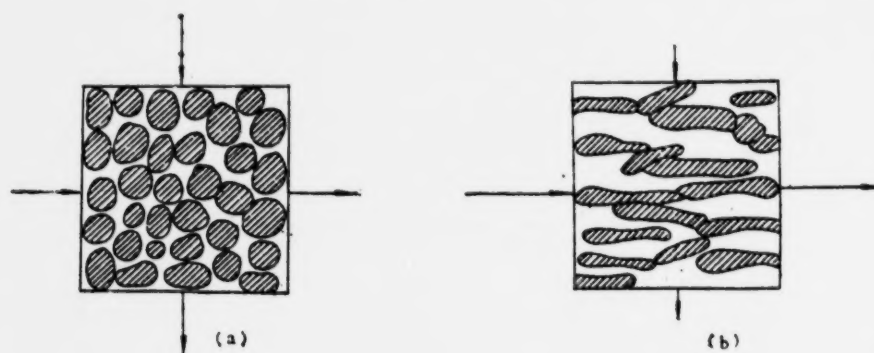


Figure 2. Structure of granular sediment buildup and inter-granular pore orientation; arrowheads indicate the direction of sound wave propagation
 (a) ideal isotropic structure of sediment and particle axes; pores have no dominant orientation; sound velocity in each direction is equivalent
 (b) the long axes of the particles and the pore shapes have a definite dominant orientation; sound velocity varies in each direction

Nevertheless, regardless of Toksoz's pore shape spectrum and the aspect ratio, or the pore structure factor, K , correction applied by Wei Moan and Zhu Zhengya to the Wyllie model, each must make accurate measurements of pore size and shape, again carry out statistical operations, and definitely include the differences of the aspect ratios. This requires the use of water or oil saturation of future samples, or use of vacuum manometer methodology, even to the point of using the method of vacuum impregnation of colored organic glasses, and the microscopic examination of pore shapes, and more calculations of their horizontal and vertical contrast, α , or pore structure parameter, K . This way of doing things is not only technologically tedious, it's also difficult to obtain solutions to practical problems. Moreover, one must guess at the porosity, the aspect ratio, and the pore structure in a statistical distribution which is homogeneous, particularly in regard to the effect of a closed pore medium which does not allow a way to carry out an observation. All this limits the practical use of the theory and also limits further advances in this aspect of the research.

II. Sediment Mechanical Parameters and Velocity of Sound Data

Since 1980, at a 2100 square kilometer area of the continental shelf in the northwest section of the South China Sea (60 kilometers east-west by 35 kilometers north-south), we carried out a series of gravitational column samplings of ocean floor sedimentation, included work on an ocean floor acoustics investigation, and researched the physical-mechanical characteristics of this ocean bed material. Figure 3 shows the distribution of the column sampling points and the sound velocity measuring points within the investigated area of ocean. Analytical test results of each earth-mechanical parameter and elasticity parameter of this area of ocean floor sediment are listed in Table 1 and Table 2.

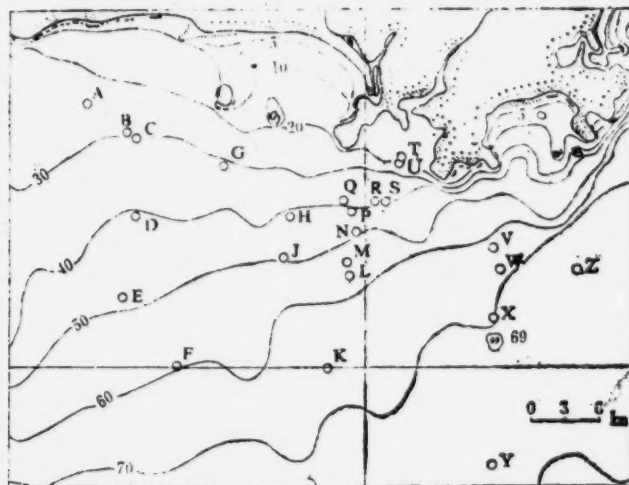


Figure 3. Distribution of test points in the experimental ocean area

The sediment mechanical parameters listed in Table 1 are all according to the People's Republic of China 1979 issue of SDS 01-79 soil mechanics regulations for carrying out testing and test conclusions; errors are all compatible with regulation requirements. The included specific gravity, G , is the specific gravity as measured by the bottle method; experimental results indicate that in the sediment in this area of ocean, the variation in specific gravity values is not large; it is near the average specific gravity of quartz and the carbonate type minerals. The determination of the unidimensional compressive strength, q_u , besides the previously discussed soil mechanics regulation for carrying out testing, is according to the Ministry of Geology and Mineral Resources, System Unit 9 Rock and Acoustics Group's methods regarding the handling of test data. Table 2 includes important parameters generally used to establish the ocean floor sediment elastic model which is usually used. Table 3 lists the sound velocity values of several of the present experimental ocean area's representative test sites as determined by reflectance methods²⁾. Sound velocity data from the other test sites can be found in Table 2 of Reference [11].

2) In this experimental ocean area, sound velocities below the ocean floor surface were all determined from reflectance data.

Table 1. Average Mechanical Parameters in a 100 cm Layer of Sediment in the Experimental Ocean Area

Data Classification*	Porosity		Water Content	Wet Density	Specific Gravity	Particle Diameter	Unidimensional Compressive Strength	Flow Limit	Plasticity Limit	Plasticity Index
	n(%)	e					q_u (kg/cm ²)	W_L (%)	W_p (%)	Ip
1	55.11	1.286	46.19	1.822	2.72	5.252	0.637	33.81	19.98	14.79
2	62.4	1.660	65.81	2.440	3.08	6.780	1.480	46.90	23.00	22.30
3	42.82	0.781	19.07	1.692	2.66	3.884	0.078	24.05	14.85	9.20

* Data Classification: 1--average value, 2--maximum value, 3--minimum value

Table 2. Average Elasticity Parameters in a 100 cm Layer of Sediment in the Experimental Ocean Area

Data Classification*	Characteristic Impedance	Compression Coefficient	Volumetric Modulus	Lame Constant	Poisson Ratio	Shear Modulus
	Z (g/cm ² ·s·10 ⁵)	β	κ (dyne/cm ² ·10 ¹⁰)	λ	σ	μ (dyne/cm ² ·10 ¹⁰)
1	2.776	0.234	4.326	4.340	0.499	0.149
2	3.050	0.266	5.588	5.875	0.542	--
3	2.532	0.179	3.765	3.609	0.419	--

* Data Classification: 1--average value, 2--maximum value, 3--minimum value

Table 3. Some Representative Test Site Sound Velocity Data From the Experimental Ocean Area (based on Reference [11])

Test Site Designation	T		S		F		V	
Water Depth (m)	20		39.5		60		69	
Month of Observation	Oct 1980		Oct 1980		Sep 1981		Mar 1980	
Sound Velocity in Bottom Layer of Ocean Water, c_0 (m/s)	1539.7		1540.3		1538.7		1530	
Sound Velocity in Layers of Ocean Floor Sediment, c_1 (m/s)	Depth (m)	Sound speed (m/s)	Depth (m)	Sound speed (m/s)	Depth (m)	Sound speed (m/s)	Depth (m)	Sound speed (m/s)
(depth is figured from the ocean floor surface)	0	1514	0	1520	0	1530	0	1520
	1.94	~1685	9.2	~1575	2.35		1.3	1543
	98		30		3.4	1663	1.5	1551
	>98	4800	>30	1705	>3.4	1663	2.3	1569
							2.7	~1585
							36	
							>36	1701

III. Mechanical Factor, q_u , Which Influences the Velocity of Sound

R.S. Anderson[5] has extensively investigated each physical-chemical property of sediment which influences sound velocity. These include the specific gravity, G , the carbon content, C , the porosity, n , the water content, ω , the porosity ratio, e , the average particle diameter, ϕ , the particle group kurtosis, K , the skewness, SK , the weight of moisture, etc., but, except for porosity, none has given very satisfying results. Merely according to the data calculated from empirical formulae dealing with the porosity-sound velocity relationship (for example, the double parameter equations, $f(c,n) = 0$, of Anderson and Hamilton, etc.), still there is a relatively large difference in values with the actual sound velocity measurements due to non-linear relationships. This was already pointed out by Zhou Zhiyu [0719 1807 1946] et al. in 1983[11]. In addition, the results we obtain in the laboratory by repeatedly applying acoustical rock parameter determining instrumentation to samples, clearly show that the difference in sound velocity with the same

sample (horizontal and vertical directions) at its maximum could reach 150 to 200 meters/second; this cannot be explained using porosity alone³⁾. Thus, it is clear that, besides porosity, there are still more independent parameters which influence sound velocity.

Based on previous analysis, we differed from Anderson and adopted other approaches to a solution to the problem. We took the soil mechanical parameters of sediment, including the flow limit, W_L , the plasticity limit, W_p , the plasticity index, I_p , and the unidimensional compressive strength, q_u , etc., along with the porosity parameter, n , and carried out regression analysis on the relationships to sound velocity, c , via a computer. Results clearly show that taking the sediment compressive strength, q_u , as a supplementary factor when using the porosity, n , to calculate sound velocity, compared to merely using the porosity factor, there is a better degree of correlation. For example, in comparison with Anderson's empirical formula^[5] which is based on just ocean sediment sound velocity and porosity, when q_u is added as a third parameter and applied to calculation of the sound velocity in this ocean area, the standard deviation is lowered to 14.9 m/s from the 35 m/s of the Anderson formula; relative error is less than 0.95 percent. Then the three parameter regression formulas we obtain from our work in this ocean area has the following form:

$$f(c, n, q_u) = c - 4195 + 90.5833n - 0.7695n^2 + 94.6968q_u - 64.4603q_u^2 = 0. \quad (4)$$

Our calculation model is shown in Figure 4. Taking experimental ocean area test site V as an example, a comparison of calculations of sediment sound velocity using Equation (4) and other often used formulae can be inspected in Table 4.

The implications of Equation (4) are such that in practice there is the possibility for the statistical characteristics of microscopic pore structure to be reflected in the macroscopic whole, and supplementary revised results of ocean floor sediment sound velocity calculations will be obtained. q_u is just this kind of mechanical factor which can reflect microscopic pore structure as well as the nature of the granular buildup and the comprehensive effects of the state of mechanical coupling, when used as a supplementary term in calculations of the sound velocity, c .

In order to further examine the utility of Equation (4), we used it to calculate data from layers from several other positions in this ocean area.

3) Liang Yuanbo and Lu Bo, "Acoustical and Mechanical Properties of Shallow Ocean Floor Sediment," 1983.

Test Site V Media Parameters

Layer #	Layer thickness (cm)	Sediment type	Porosity (%)	Average particle diameter (mm)
I	34	sticky earth	57.0	0.0810
II	36	powdery sand	56.6	0.0545
III	24	sticky earth	59.3	0.0560
VI	36	sticky earth	48.6	0.0680

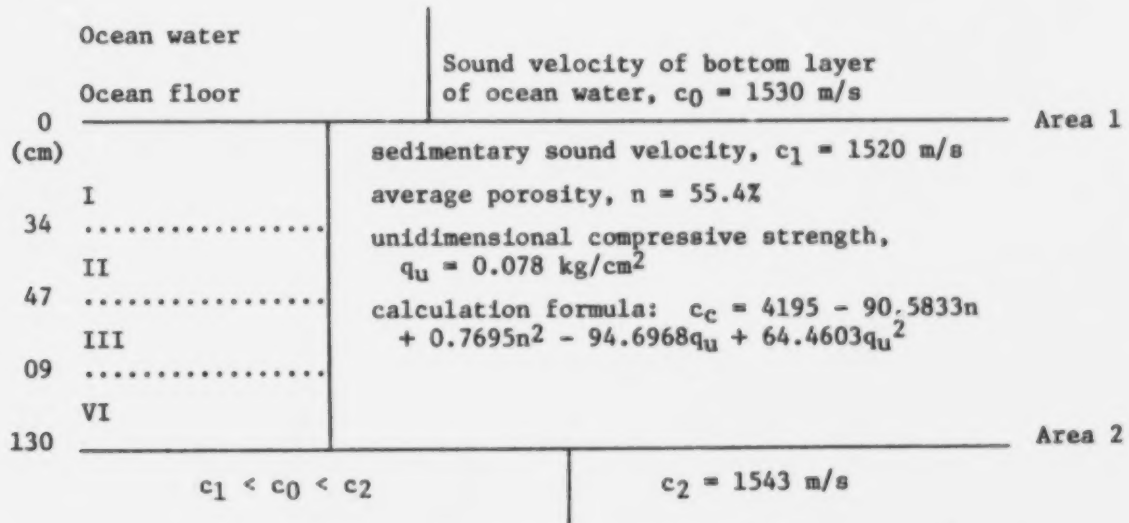


Figure 4. Media Parameter Model

Table 4. Comparison of Various Calculation Results on Sedimentary Layers in the Experimental Ocean Area

Test Site	On-site Experimental Sound Velocity c_1 (m/s)	Porosity n (%)	Unidimensional Compressive Strength q_u (kg/cm ²)	Formula	Calculated Results, Sound Velocity c_c (m/s)	Deviation* Δc (m/s)
V	1520	55.4	0.078	1. Anderson Formula [6]: $c = 2506 - 27.58n + 0.1868n^2$	1551.4	+31.4
				2. Hamilton Formula [8]: $c = 2455.9 - 21.716n + 0.126n^2$	1639.5	+119.5
				3. Formula cited in Reference [2]: $c = 2475.5 - 21.764n + 0.123n^2$	1647.3	+127.3
				4. Formula (4) of this work: $c = 4195 - 90.5833n + 0.7695n^2 - 94.6968q_u + 64.4603q_u^2$	1531.3	+11.3

$$*\Delta c = c_c - c_1$$

Results were as follows (same units as in Table 4):

Test Site	Layer (cm)	n	q_u	c_c	c_1	Δc
F	43	59.1	0.151	1516	1530	14
L	60	62.2	0.451	1507	1520	13
U	40	62.4	0.754	1504	1514	10

Δc is within the range of the standard deviation.

IV. Some Discussion

The physical significance of Equation (4) is easy to understand because taking q_u as the upper limit of a sediment's resistance to vertical pressure, it is certainly one of the intrinsic physical-mechanical properties (or characteristics) of natural sediments; it is, due to the granular composition of the porous media, a determining factor of the pattern of granular buildup and the state of mechanical coupling. Then, speaking of relatively broad diameter particles on powdery sand, the important effective elements are the internal friction of the solid particles, and the cementing effect. As for the pattern of granular buildup, although Gratton and Fraser^[12] analyzed buildup in simple spherical systems and found that there are six common and important patterns, and that sediment is influenced by density and unit weight, natural sediments rarely have isometric, homogeneous, spherical buildup, leading to a situation in which there is no way to obtain a full set of factors through concrete testing (see plates 2, 3 and 4), thus, they cannot simply be accounted for using density or unit weight. Additionally, due to the cementing activity in back of the sediment (plates 5-8), one is also unable to use suspended solids equations for mineral particles in sea water to describe sedimentation (Reference [16], pp 7-11).

We have taken another look at what happens in the situation where we merely use q_u and don't consider the porosity. Gen An [2704 1489] and others have dealt with rock cores from Hokaido, Japan as well as rock experiments carried out in several of our large test areas by China's Ministry of Geology and Mineral Resources, System 9 Unit Rocks and Acoustics Group. Their results are as follows:

$$\lg(q_u) = 2.671 \lg(c_u) + 1.09$$

or,

$$q_u = 12.3 c_u^{0.37} \quad (5)$$

which omits the effect of the rock porosity on sound velocity. This type of double parameter formula ($f(c, q_u) = 0$) deals with this problem from a different approach, but its results are applicable only in cases of the lowest porosity (for example, $n < 10\%$), since in this case the sound waves are basically propagating through a solid framework. Moreover, the few empirical formulae discussed above apply to test results of igneous rocks and metamorphic rock layers. But, speaking in terms of the water-saturated porous media of contemporary ocean sedimentation, the porosity, n , cannot be neglected. This point has already been amply expounded upon by Biot^[6].

In common with any of the empirical formulae, Equation (4) was established from test data from specific experimental ocean areas and its coefficients in different ocean areas can have some variation. Our work, and the above analysis, just point out one way to deal with this; namely q_u is an effective factor which, together with the porosity, n , conditions the velocity of sound propagation in ocean waters. It naturally includes the macroscopic effect of the pore structure of the porous media. The results of our regression analysis of this area's sediment test data clearly show that this is the case.

V. Conclusion

1. Adopting the mechanical factor, q_u , comprehensively expresses the overall effects of granular buildup of ocean floor sediment and pore structure and can serve as an additional corrective factor in calculations of sedimentary layer sound velocity. It raises the calculation precision of the often used formulae which don't consider pore structure, and at the same time, it eliminates the necessity of carrying out statistical measurements of microscopic pores for correcting sound velocity calculations.

2. This work and related analyses make clear that the use of ocean floor acoustical characteristics to distinguish the engineering and mechanical properties of sedimentary layers is not only possible, but also there are broad areas which need investigation and research; for example, investigation of the relationships among the shearing strength, S , the Adebao [7093 1779 1027] liquid limit, W_L , acoustic impedance, Z , etc. As to the problem of sedimentary shear wave propagation and shear modulus, μ , we will discuss that further in a future paper. In essence, these are established through acoustical methods together with sediment mechanical properties and work dealing with relationships among geological factors. With this aspect of investigative research we can hope to more perfectly develop the technology for remote sound sensing and telemetry of ocean floor material.

The on-site sound velocity information used in this report was provided by the 1st Laboratory of the Ocean Floor Group (Comrade Zhou Zhiyu [0719 1807 1946] and others), a cooperative unit of the Institute of Acoustics, Chinese Academy of Sciences. Also work on the electron microscope observations and picture taking was received through the enthusiastic cooperation of the Electron Microscope Laboratory, Zhongshan University; for this, we express our deep appreciation.

PLATE CAPTIONS

Electron micrographs of ocean floor sediment structure:

1. Structure of near spherical and equal granular buildup (consisting of pyrite particles. South China Sea, northwest section continental shelf, ocean floor area #551, magnified 30,000 times.
2. Structure of granular buildup of natural sediment. Ibid., #262, magnified 5,000 times.
3. Structure of sedimentary pores having definite orientation. Ibid., #336, magnified 30,000 times.
4. Microscopic structure of plate-like bioclastic sediment. Ibid., #328, magnified 7,500 times.
5. Cementation of sediment particles (cementing of aragonite needles). Ibid., #686, magnified 8,000 times.

6. Microscopic structure of aragonite needle cementite. Ibid., #683, magnified 7,500 times.
7. Skeletal structure of network shape formed by aragonite needle cementite. Ibid., #352, magnified 30,000 times.
8. Filling and proliferating conditions of aragonite needle cementite among granular pores. Ibid., #361, magnified 15,000 times.

REFERENCES

- [1] Meng Jinsheng [1322 6855 3932], Guan Dinghua [7070 1353 5478], SHENGXUE XUEBAO [ACTA ACUSTICA] (English Language Edition), 1(1980),1.
- [2] Wang Dezhao [3076 1795 2507], Shang Erchang [1424 1422 2490], "Hydro-acoustics," Science Press, 1981.
- [3] Liang Yuanbo, Lu Bo, HAIYANG DIZHI YANJIU [OCEAN GEOLOGICAL RESEARCH], 1(1981),2.
- [4] Liang Yuanbo, Lu Bo, RADAI HAIYANG [TROPICAL OCEANS], 2(1983),3.
- [5] Anderson, R.S., In: "Physics of Sound in Marine Sediments," Plenum Press, 1974, 481-518.
- [6] Biot, M.A., JASA, 28(1956),2.
- [7] Wyllie, M.R.J., GEOPHYSICS, 21(1956),1.
- [8] Hamilton, E.L., In: "Physical and Engineering Properties of Deep-Sea Sediments," Plenum Press, 1974, 1-43.
- [9] Toksoz, M.N. et al., GEOPHYSICS, 41(1976): 621-645.
- [10] Zhu Zhengya [2612 2973 0068], SHENGXUE JISHU [ACOUSTICS TECHNOLOGY], 1(1982),1.
- [11] Zhou Zhiyu, HAIYANG XUEBAO [ACTA OCEANOLOGICA SINICA], 5(1983),5.
- [12] Gratton, L.C. and H.J. Fraser, JOUR. GEOL., 43(1935): 785-909.
- [13] Smith, D.T., In: "Physics of Sound in Marine Sediments," Plenum Press, 1974, 41-61.
- [14] Matviyenko, V.N. and Yu.F. Tarasyuk, "Dalnost' Deystviya Gidroakusticheskikh sredstv," Sudostroyeniye Publishing House, 1976.
- [15] Shirley, D.J. et al., "Sediment Acoustics," AD-A084738, 1980.

- [16] Kuperman, W.A. and F.B. Jensen (ed.), "Bottom-Interacting Ocean Acoustics," Plenum Press, 1980.
- [17] Sun Chengdong [1327 2052 2767], "Rock Acoustics Testing," Geological Publishing House, 1981.

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PHYSICAL SCIENCES

COMPARISON OF DEEPWATER WIND-WAVE PREDICTION MODELS

Qingdao SHANDONG HAIYANG XUEYUAN XUEBAO [JOURNAL OF SHANDONG COLLEGE OF OCEANOLOGY] in Chinese Vol 15 No 3, 15 Sep 85 pp 1-11

[Article by Wang Bingxiang [3076 3521 4382], Zhang Jiuzi [1728 1432 5417], Department of Physical Oceanology and Marine Meteorology, and Wu Guiqiu [2976 2710 4428], First Institute of Oceanography, National Bureau of Oceanography: "Comparison of Deepwater Wind-Wave Prediction Models"; paper received 5 May 1984]

[Text] English Abstract: Presently, there are about 36 models used in deep-water wind-wave forecasting by incomplete statistics. To select from among these models 12 that are more important and currently employed are confirmed by field observations, and are compared with each other. The calculations based on the 12 have been compared with wave data proffered by Iu.M. Krylov (1958) and Bao Qiangsheng et al. (1983); so far as the cases examined are concerned, the accuracy of the results given by Wang's model are superior to those of the other 11 models. In order to investigate typhoon waves at station "Xiaomaidao" at 1800 hours 30 August 1939, the above approaches to wave prediction are used to hindcast again; the wave height on a basis of Wang's model is found to be more consistent with a 50-year return period wave at the wave station than those found for the existing models. According to the prediction technique of hurricane waves the wave height and period of the most probable first highest wave within the area of the typhoon are estimated at about 39 meters and 24 seconds respectively.

Ocean wave wave height and period are two important parameters in marine engineering site selection and structure design. There are generally two applications of these two wave factors obtained for a designated region: One is if there are already wave observation materials, then spectrum or non-spectrum methods can be relied on; the other is if there are no materials, then with the help of wave materials for neighboring marine regions, they can be deduced using refraction-diffraction theory or, after determining the wind factors from historical weather maps, they can be hindcast using wave forecast methods. We followed the second method in the second category to estimate the marine typhoon wave factors.

Since Sverdrup and Munk first published their method for forecasting effective wave in 1974¹, many methods have been proposed. Counting only those in references 2-10 there are 36. Although there are so many forecasting models, they can be reduced to two categories: quasi-experimental and purely experimental. We selected 12 of the more important ones which are frequently used, for verification and comparison and carried out a wind-wave hindcast based on a strong typhoon in the history of the Huanghai.

For the verification which was carried out on each method using the materials published in Table 2 of reference 6 and Table 1 of reference 11, the method of reference 4 provided better results than the other methods.

The methods were applied to hindcasting typhoon waves at Xiaomaidao at 1800 hours on 30 August 1939; based on the results of the method in reference 4, conformity to the observation values was better than the other methods. As concerns the results obtained using the hurricane wave forecast methods, the maximum probable values of the wave height and wave period within the typhoon area are 39.3 meters and 24.19 seconds, respectively.

I. Verification and Comparison of Models

1. The models were verified on the basis of the data provided in Table 2 of reference 6 and Table 1 of reference 11.

Apart from the eight models in references 3, 4, and 6, 4 of the 12 models used were newly selected for uniform units, and after conversion were

(1) G.B. Rzhaplinskii (1972)¹²:

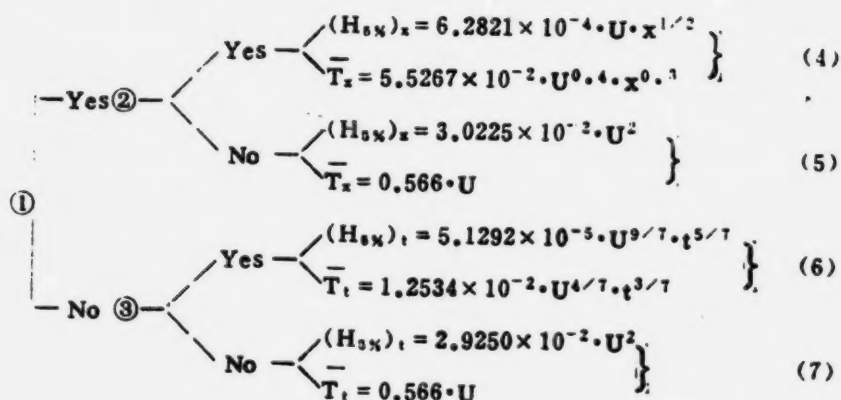
$$\left. \begin{aligned} (H_{5\%})_x &= 1.7872 \times 10^{-3} \cdot U^{4/3} \cdot x^{1/3} \\ T_x &= 0.1126 \cdot U^{3/5} \cdot x^{1/5} \end{aligned} \right\} \quad (1)$$

$$\left. \begin{aligned} (H_{5\%})_t &= 6.6911 \times 10^{-4} \cdot U^{19/12} \cdot t^{5/2} \\ T_t &= 6.1437 \times 10^{-2} \cdot U^{3/4} \cdot t^{1/4} \end{aligned} \right\} \quad (2)$$

(2) B.W. Wilson, W (1965)¹⁰:

$$\left. \begin{aligned} (H_{5\%})_x &= 3.7277 \times 10^{-2} \cdot U^2 \cdot [1 - (1 + 1.2528 \times 10^{-2} \cdot U^{-1} \cdot x^{1/2})^{-2}] \\ T_x &= 0.7590 \cdot U \cdot [1 - (1 + 1.7126 \times 10^{-2} \cdot U^{-2/3} \cdot x^{1/3})^{-5}] \end{aligned} \right\} \quad (3)$$

(3) D.J.T.Carter(1982)^[14]:



in which

$$\textcircled{1} \quad t > 33.3713 \cdot U^{-0.4} \cdot x^{0.7}$$

$$\textcircled{2} \quad x < 2.32 \times 10^3 \cdot U^2$$

$$\textcircled{3} \quad t < 7.2306 \times 10^3 \cdot U$$

(4) The method in reference 2 (abbreviated QQQ) (1980):

$$\left. \begin{array}{l} (H_{5\%})_x = 3.4786 \times 10^{-2} \cdot U^2 \cdot [1 - \exp(-2.5057 \times 10^{-2} \cdot U^{-1} \cdot x^{1/2})] \\ \bar{T}_x = 3.645 \sqrt{H_{5\%}} \end{array} \right\} \quad (8)$$

The units U (wind velocity), x (wind area), and t (wind time) in equations (1)-(8) are, respectively, m/sec^{-1} , meters, and seconds; the $H_{5\%}$ (accumulation rate is 5 percent of wave height) and $\bar{T}$ (average period) units are meters and seconds, respectively.

The wave data in Table 1 of reference 11 was used in references 3, 4, 6, and 13; the wind factors given in this table were substituted in the relevant forms in equations (1)-(8). The results of the wave factors calculated are given in Table 1.

From the figures in Tables 2 and 3 we know that the wave height given by the method in reference 4 is better than the other methods.

Here we should explain that conversion between the wave heights was induced according to theoretical results¹⁵, i.e.,

$$\left. \begin{array}{l} H_{5\%} = 1.95 \bar{H} \\ H_{\frac{1}{10}} = 2.032 \bar{H} \\ H_{1/3} = 1.598 \bar{H} \end{array} \right\} \quad (9)$$

Table 1. Comparison of Methods

No	1. 深度 (米)	2. 风速 (米/秒)	3. 风时 (小时)	4. 风区 (公里)	5. 波 高 (H _{5%}) 米					6. 周 期, 秒				
					P	C	WIL	QQQ	7. 观测	P(T)	C(T)	WIL(T)	QQQ(T)	7. 观测 (T _{5%})
1	140	6	18	200	1.13	1.05	0.98	1.05	0.7	3.78	3.39	3.34	3.75	3.7
2	76	7	10	250	1.15	1.12	1.31	1.40	1.0	3.64	3.41	3.85	4.34	3.8
3	193	7	17	400	1.43	1.43	1.42	1.52	1.2	4.15	3.96	4.10	4.50	4.7
4	180	8-9	4	40	1.06	0.75	1.03	1.11	1.0	3.38	2.57	3.10	3.85	3.6
5	180	8-9	12	40	1.06	1.06	1.08	1.11	1.0	3.38	3.12	3.10	3.85	3.6
6	43	8-9	18	200	1.81	2.11	1.71	1.83	1.5	4.67	4.81	4.25	4.94	—
7	—	8-9	3	400	0.94	0.61	1.97	2.11	0.9	3.11	2.27	4.73	5.31	—
8	—	8-9	9	400	1.50	1.33	1.97	2.11	1.4	4.10	3.64	4.73	5.31	4.0
9	—	8-9	16	400	1.90	2.01	1.97	2.11	1.8	4.73	4.67	4.73	5.31	4.2
10	450	8-9	22	400	2.17	2.11	1.97	2.11	1.8	5.13	4.81	4.73	5.31	4.2
11	30	9	11	120	1.85	1.86	1.64	1.74	1.4	4.36	4.10	4.03	4.81	4.0
12	30	9	18	120	1.65	1.95	1.64	1.74	1.5	4.36	4.44	4.03	4.81	4.6
13	86	9-10	4	70	1.27	0.86	1.51	1.56	1.3	3.64	2.74	3.73	4.57	3.2
14	86	9-10	5	70	1.40	1.02	1.51	1.56	1.3	3.85	3.02	3.73	4.57	3.2
15	86	9-10	9	160	1.79	1.54	1.92	2.03	1.8	4.46	3.88	4.39	5.21	4.5
16	86	9-10	11	160	1.94	1.78	1.92	2.03	1.8	4.68	4.23	4.39	5.21	4.5
17	220	10-11	12	170	2.27	2.15	2.26	2.40	2.0	5.13	4.85	4.73	5.64	5.1
18	43	11	26	200	2.55	3.09	2.53	2.67	2.0	5.45	5.61	5.02	5.97	—
19	61	11-12	14	400	2.91	3.70	3.20	3.44	2.9	5.74	5.24	5.84	6.76	6.0
20	61	11-12	18	—	3.23	3.24	—	—	2.9	6.10	5.84	—	—	6.0
21	60	12	3	30	1.52	0.95	1.51	1.50	1.1	3.93	2.77	3.49	4.49	3.7
22	60	12	7	30	1.52	1.30	1.51	1.50	1.1	3.93	3.29	3.49	4.49	3.7
23	220	12	18	150	2.60	2.91	2.64	2.77	2.0	5.42	5.33	5.01	6.07	—
24	240	12	26	600	4.03	4.21	3.72	4.00	3.4	6.92	6.79	6.41	7.30	6.0
25	85	12	2.5	180	1.51	0.83	2.78	2.92	1.2	3.85	2.56	5.20	6.25	3.7
26	85	12	5	180	2.02	1.37	2.78	2.92	1.8	4.58	3.45	5.20	6.25	4.3
27	85	13	7	180	2.64	1.93	3.12	3.28	2.2	5.29	4.17	5.45	6.60	5.3
28	85	13	8	180	2.80	2.12	3.12	3.28	2.2	5.47	4.42	5.45	6.60	5.3
29	85	14	10	180	3.40	2.74	3.46	2.63	2.5	6.16	5.07	5.70	6.94	5.6
30	85	15	12	180	3.73	3.41	3.81	3.96	3.1	6.43	5.71	5.94	7.26	6.0
31	85	15	13	180	3.73	3.61	3.81	3.96	3.3	6.43	5.91	5.94	7.26	6.4
32	60	13	22	400	4.02	4.37	3.86	4.13	2.9	6.92	6.82	6.33	7.41	6.4
33	38	14	11	170	3.34	2.93	3.40	3.55	2.5	6.09	5.29	5.63	6.87	—
34	85	14	11	180	3.40	2.93	3.46	3.63	2.5	6.16	5.29	5.70	6.94	5.6
35	2415	14	14	600	3.97	3.48	4.75	5.11	4.0	6.66	5.86	7.12	8.24	—
36	3780	14	20	1000	4.61	4.49	5.27	5.67	3.7	7.28	6.83	7.70	8.68	6.5
37	340	15	13	300	4.30	3.61	4.43	4.68	4.1	6.88	5.91	6.58	7.89	7.0
38	340	15	16	300	4.42	4.19	4.43	2.68	4.1	7.12	6.46	6.58	7.89	—
39	67	15	18	400	4.87	5.96	4.80	5.11	4.5	7.54	7.82	6.97	8.24	7.0
40	—	15	4	300	2.63	1.55	4.43	4.68	1.9	5.12	3.56	6.58	7.89	4.8
41	96	16	20	30	2.23	1.74	2.14	2.11	1.4	4.67	3.69	4.02	5.30	—
42	38	16	14	170	3.99	4.14	4.08	4.23	3.5	6.60	6.33	6.09	7.50	—
43	6370	20	20	300	6.49	6.89	6.64	6.90	5.5	8.46	8.05	7.81	9.58	—
44	3350	21	25	900	9.62	8.88	9.73	10.39	9.0	10.43	9.48	9.97	11.75	—

[Key on following page]

Key:

- | | |
|------------------------|--|
| 1. Depth (meters) | 5. Wave height (H _{5%}) meters |
| 2. Wind velocity (m/s) | 6. Period, seconds |
| 3. Wind-time (hours) | 7. Observations |
| 4. Wind area (km) | |

Note to Table 1: The letters SM, B₁, K, PNJ, WEN, WANG, B₂, NOR, P, C, WIL and QQQ in Tables 1, 2, and 3 represent the methods of Sverdrup-Munk (1947), Bretschneider (1952), Krylov (1958), Pierson-Neumann-Japnes (1955), Wen Shengchang (1960), Wang Bingxiang (1964), Bretschneider (1970), norm (1978), Rzhaplinskii (1972), Carter (1982), Wilson (1965), and the Shandong College of Oceanography-First Institute of Oceanography-Institute of Oceanography of the Academy of Sciences (1980), respectively. When these letters appear later in this paper, they carry the same meaning.

Table 2. Maximum Error of Wave Height Calculated According to Table 1*

(1) 方 法	(2)波高的最大误差	
	%	NO
SM	109.6	41
B ₁	82.9	41
K	78.6	41
PNJ	75.0	18
WEN	41.1	7
WANG	35.0	41
B ₂	61.0	22
NOR	51.0	40
P	61.4	1
C	50.0	1
WIL	133.2	40
QQQ	146.3	40

*SM, B₁, K, PNJ, WEN, WANG and B₂,
NOR are taken from references 4 and 6.

Key:

1. Method
2. Maximum wave height error

Table 3. Maximum Error of Wave Height of the Various Methods Calculated in Table 2 According to Reference 6*

(1) 方 法	(2) 波高的最大误差	
	%	NO
SM	100.0	12
B ₁	98.0	8
K	52.0	7
PNJ	106.0	2
WEN	46.0	3
WANG	32.0	5
B ₂	55.0	2
NOR	51.0	12
P	61.8	2
C	42.3	2
WIL	81.7	1
QQQ	93.2	2

*Cited according to reference 6 except for P, C, WIL, and QQQ.

Key:

1. Method
2. Maximum wave height error

The relationship between periods is according to experimental equation¹⁶

$$T_1 = 1.156 \bar{T} \quad (10)$$

This value is almost equivalent to the 1.15 of reference 17.

2. It was difficult to carry out a systematic comparison of the models. The main difficulty was that of the 12 methods to be compared in the paper, if we relied on the wind-wave dimensions for their growth stage we were restricted to three essential divisions of wind, the three were: 1, simultaneously relative wind area and wind time growth⁴; 2, only relative to wind area growth^{2,10}; 3, growth relative to either the wind area or wind time. To overcome this difficulty and get on with the comparison, first of all, we handled it as reference 3 in comparing this item, and selected only one representative wind velocity, for example, 15 m/sec⁻¹; next, since there were two in the paper which were only relative to wind area growth, and therefore for wave theory of growth relative to their wind area or wind time, we took only the expression for the former; for processing reference 4, two wind times were provided: one was the wind time (3.42 x 10⁵ sec) necessary for the wind wave to achieve full growth at the corresponding wave velocity of 15 m/sec⁻¹, and the other was 10² sec, which was changed into only relative to wind area growth.

In Figures 1 and 2, the series marked WEN, SM, B₁, K, and PNJ reproduce Figures 7.7-3 in reference 15, the rest are calculated and drawn using various methods.

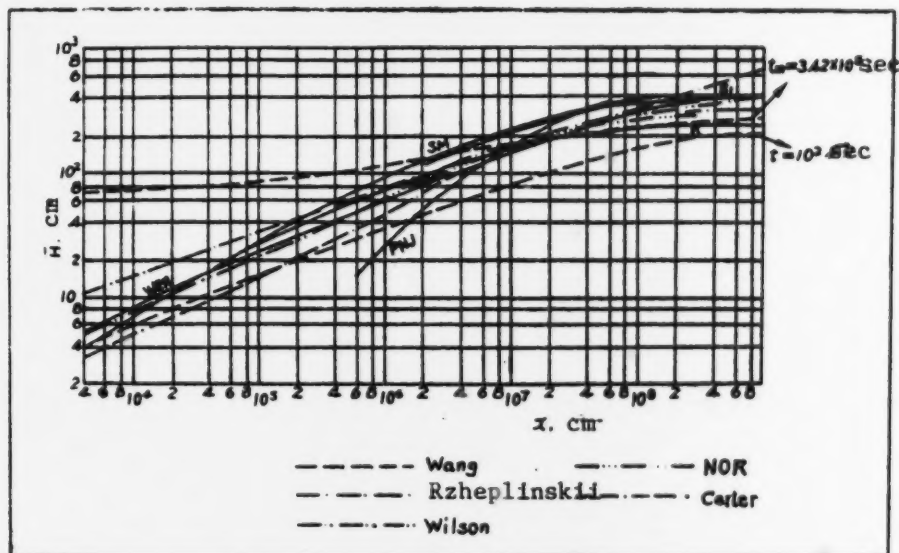


Figure 1. Comparison of Wave Height of Various Methods With Growth of Wind Area

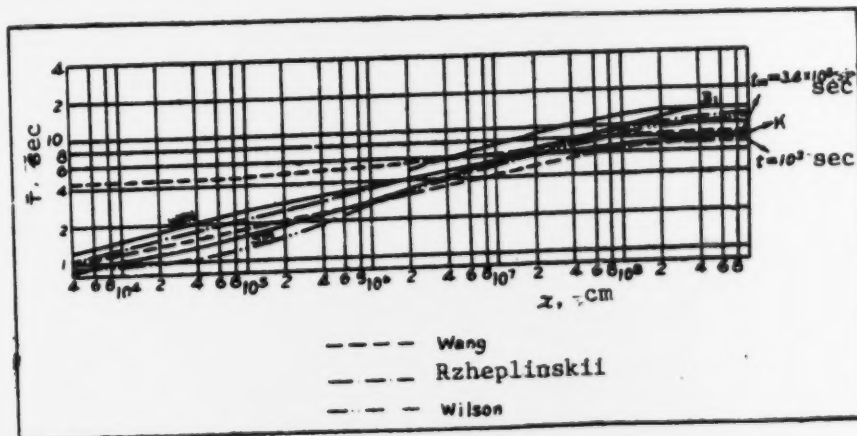


Figure 2. Comparison of Wave Period of the Various Methods With Growth of Wind Area

From the curve in Figure 1 the following characteristics can be seen: 1) The K curve from beginning to end is within the upper and lower limits of the Wang curve; 2) the Carter and PNJ curves are both below the lower limits of the Wang curve when the wind region length is smaller than 10^5 cm and

2×10^6 cm, respectively; 3) the SM curve first goes 30 km beyond the upper limit of the Wang curve, and continues to go beyond it, next are the B_1 , Wilson, Rzheplinskii, NOR, B_2 , Carter, and PNJ curves, and finally 300 km beyond it is the WEN curve.

Because the lines in the figure are so concentrated, there isn't any way to draw the B_2 curve, therefore it is explained below: 1) within the 3-200 km range, B_2 is slightly higher than WEN and slightly lower than K; 2) from 500 km it almost overlaps WEN and is higher than K; 3) in between 3 and 2000 km, is lower than B_1 .

The curves in Figure 2 reveal: 1) B_1 initially goes beyond the upper limit of the Wang curve, those which continue to go beyond it next are NOR, SM, Rzheplinskii and Wilson; 2) in the wind region under discussion, WEN and K throughout are located between the upper and lower limits of the Wang curve; 3) SM and Wilson are below the lower limit of the Wang curve when the wind area is smaller than 6 km and 10 km respectively.

Three interesting relationships must be explained here: 1) At $4 \times 10^3 < X < 10^4$ cm, the Carter and Wilson period curves are both almost congruent; at $2 \times 10^4 < X < 10^7$ cm, the former is lower than the latter; at $10^7 < X < 10^8$ cm, it is the reverse; when $X > 10^8$ cm, the former is again lower than the latter. 2) At $X < 440$ km, NOR is higher than SM and Rzheplinskii; at $X > 400$ km, it is the opposite. 3) At $3 < X < 60$ km, $B_2 > SM$; at $X > 60$ km, $K < B_2 < SM$; B_2 is always lower than B_1 .

From Figure 1 and Figure 2 it can be clearly seen that wind area and wind time have an influence on the wave height and period computed on the basis of the method in reference 4; when the wind area is short, wind-wave dimensions increase very rapidly with the wind time, and when it is long, the role played by the wind time gradually diminishes until $X = 3240$ km, the wind time effect becomes so weak that even the wind height and period at $t_m = 95$ hours and $t = 10^2$ seconds, are respectively 2.68 m and 2.00 m and 8.22 seconds and 7.10 seconds.

II. Hindcast of Huang Hai Typhoon Waves

In summer and autumn China's Huang Hai is occasionally hit by typhoons giving rise to typhoon waves, which have a catastrophic impact on China's coast¹⁸.

A survey of historical materials on typhoons reveals that in the 84 years of this century the one whose impact on the southern coast of Shandong was most severe was the typhoon that went through the Huang Hai on 28-31 August 1939. It goes without saying that the dimensions of the typhoon waves which accompanied it also should be the largest. So, how high and how long were its wave height and period? On the one hand, this paper used the 12 models verified and compared in the previous section to hindcast the typhoon waves at Xiaomaidao at 1800 hours on 30 August 1939, and on the other hand relying on wave factors provided by the hurricane wave forecast methods¹⁹ for the first largest wave likely within the typhoon area, we attempted to give a probable answer to this question.

The present problem is how to determine the wind area, wind velocity, and wind time required by wind-wave forecasts.

Since the wind velocity materials of the surface temperature map of 1800 hours on 30 August 1939 given in Figure 3 is far from able to satisfy the demands of wind-wave forecasting, we followed the read-outs of the wind velocity curve of the Qingdao meteorological station and after calculation treated the values obtained as the wind velocity required.

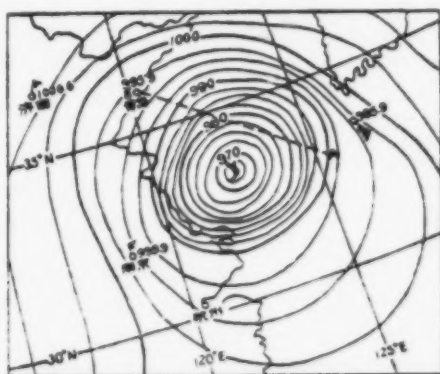


Figure 3. Weather Map of 1800 Hours (Beijing time) 30 August 1939

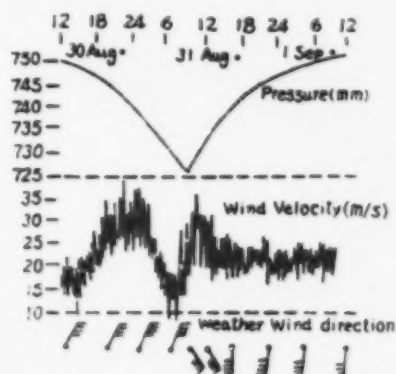


Figure 4. Chart of Meteorological Changes at Qingdao 30 August-1 September 1939 (cited from Figure 3 in reference 18)

From the curve in Figure 4 we read the average wind velocity at 1200 hours and 1800 hours on the 30th as $U_1 = 17.5 \text{ m/sec}^{-1}$ and $U_2 = 27 \text{ m/sec}^{-1}$, then using the formula for when the wind velocity continues to increase we solved for the representative value between 1200 and 1800²⁰:

$$U(Z_1)_1 = 0.2U_1 + 0.8U_2 = 25.1 \text{ m/sec}^{-1} \quad (11)$$

which is 0.6 m/sec^{-1} greater than the lower limit for a force 10 wind (24.5 m/sec^{-1}). Experience tells us that the wind velocity over the sea is greater by one or two grades than over the land. Thus, we took its upper limit, i.e., 2 grades, because from Figure 3 the wind area under consideration was situated on the right side of the typhoon's direction of advance, which was the area where the wind velocity was greater than its left side¹⁹. Therefore, the wind at sea corresponding to the Qingdao Guanxiangshang wind velocity meter, a point 103.8 meters above sea level (Z_1) the wind was the lower limit (32.7 m/sec^{-1}) of force 12 plus 0.6 m/sec^{-1} , i.e., $U(Z_1) = 33.3 \text{ m/sec}^{-1}$.

According to the vertical distribution of wind velocity, we found the wind velocity at a point (Z_2) 10 meters above the surface of the sea¹⁸:

$$U(Z_2) = U(Z_1) \cdot \left[\frac{\log Z_2 - \log Z_0}{\log Z_1 - \log Z_0} \right] = 26.54 \text{ m/sec}^{-1} \quad (12)$$

in which $Z_0 = 0.001$ is the Ellison's observation value at the sea surface.

The wind area relies on the idea of the most favorable line wind area¹⁷, and is determined by reference to the wave propagation direction, i.e., in Figure 3, $AB = 350$ nautical miles.

Determination of the wind time will involve equivalent wind time t_e , for the same wave height and wave velocity, different methods will give individual values, and thus are related to the wind-wave dimensions sought. For purposes of simplification, this paper takes the norm as the standard. Assuming that at 1200 hours on 30 August the typhoon had not yet reached the area under discussion but already had waves with wave height of 5 m¹⁸. This value together with wind velocity $U(Z_2)$ can be found from the norm $t_e = 2.2$ hours, thus we obtain the forecast of 30 August's wind-wave wave time as 8.2 hours.

The wind factors obtained were substituted in the 12 models in the previous section to hindcast the wind-waves at Xiaomaidao at 1800 hours on 30 August 1939. The results are given in Table 4.

Table 4. Comparison of Various Methods for Wind-Wave*

1. 日期 1939年8月	2. 风速 (米·秒 ⁻¹)	3. 风时 (小时)	4. 风区 (公里)	5. 波 高 ($H_{1/10}$) 米											
				SM	B ₁	K	PNJ	WEN	WANG	B ₂	NOR	P	C	WIL	
30-1800	26.54	8.2	648	10.30	10.17	9.55	8.10	10.09	7.52	8.13	9.0	9.12	8.64	12.99	
(7) 百分误差(%)				43.0	41.2	32.8	15.3	40.1	4.4	12.9	25.0	26.7	21.7	30.4	

6. 周 期 (T) 秒															
QQQ	H°	SM	B ₁	K	PNJ	WEN	WANG	B ₂	NOR	P	C	WIL	QQQ	T°	
13.51	7.2	6.49	9.78	9.4	8.5	8.46	9.05	8.56	10.8	9.4	6.72	10.80	13.16	11.2	
87.6		42.0	12.7	16.1	24.1	24.5	13.8	23.6	3.6	16.1	40.0	3.6	17.5		

*These data are cited from reference 21 Xiaomaidao 50-year return period design wave factors.

Key:

1. Time: August 1939
2. Wind velocity: (m/sec⁻¹)
3. Wind-time: (hours)
4. Wind area (km)
5. Wave height ($H_{1/10}$) meters
6. Period (T) seconds
7. Percentage error (%)

If we make the Xiaomaidao 50-year return period design wave factor as the criterion, then from the figures in Table 4 we can tell that: 1) In terms of percent error, the errors of the various methods are smaller than the corresponding methods in Table 2 and Table 3, this seems to mean that the

method of determining wind factors is rational and thus the values obtained conform to reality. 2) The wave height values provided using the model in reference 4 are better than the other models, but the best period values are at the same time provided by the norm²⁰ and Wilson method¹⁰. 3) The period error is smaller than the wave heights.

The model for forecasting deepwater hurricane wave¹⁹:

$$\frac{P_r - P_0}{P_s - P_0} = e^{-\frac{R}{r}} \quad (13)$$

$$U_{max} = 0.868[73 \cdot \Delta P^{0.5} - R \cdot (0.575f)] \quad (14)$$

$$U_R = 0.865 U_{max} + 0.5 V_F \quad (15)$$

$$H_{\frac{1}{3}} = 16.5 e^{\frac{R \cdot \Delta P}{100}} \cdot \left[1 + \frac{0.208 \alpha V_F}{\sqrt{U_R}} \right] \quad (16)$$

$$T_{\frac{1}{3}} = 2.13 \sqrt{H_{\frac{1}{3}}} \quad (17)$$

in which: f (Coriolis parameter) = $2\omega \cdot \sin\phi$; if ϕ is the latitude of the center of the typhoon, $33.4^\circ N$, and ω (the earth's angular velocity) = $2\pi/24$ is substituted, we get $f = -0.285$ arc·hours⁻¹.

α is a parameter which is determined by the forward velocity of a hurricane and the growth of the effective wind area, and for a hurricane moving slowly, it can be assumed to be 1.

constant pressure $p_n = 29.92$ hours¹⁹.

p_0 and p are both pressure, units both are hours.

$\Delta p = p_n - p_0$.

units of effective wave height ($H_{\frac{1}{3}}$) and period ($T_{\frac{1}{3}}$) are feet and seconds.

If we substitute the data read from the surface weather map at 1800 hours on 30 August 1939:

the typhoon center's distance r from Qingdao = 360 km;

the atmospheric pressure P_f at a point r distant from the typhoon center, i.e., the Qingdao Station, = 995.9mb* and the data cited in reference 18:

the atmospheric pressure p_0 in the center of the typhoon = 959.9mb;

the center of the typhoon advanced at the average velocity

$V_F (= 8.095 \text{ knots})$

*Document [18] misread the 30 August 1500 hours weather map time as 1800 hours, thus the corresponding errors are 434 km and 998.6mb.

in equations (13)-(17), then we get:

maximum wind velocity radius $R = 76.31$ nautical miles;
 maximum wind velocity gradient $U_{\max}$ at a point 30 feet above the sea surface = 68.43 knots;
 for the moving wind area, the maximum continuous wind velocity U_R at a point 30 feet above the sea surface = 63.24 knots;
 the effective wave height and period at the place of maximum wind velocity are, respectively,

$$H \frac{1}{3} = 20.19 \text{ meters} \quad (18)$$

$$T \frac{1}{3} = 17.34 \text{ seconds} \quad (19)$$

Assuming that according to reference 19 the most probable largest sea wave is determined by the number N of waves; and N is determined by the length of the hurricane's cross section in a zhundingchang [0402 1353 1603] state and its forward velocity. It has already been shown that the largest sea waves appeared in a range equivalent in length to the radius of the maximum velocity, and the time needed for this length to go through a typical point:

$$t = \frac{R}{V_F} = 33936 \text{ sec} \quad (20)$$

thus

$$N = \frac{t}{T_{1/3}} = 1957 \quad (21)$$

the probable maximum wave height, is calculated according to

$$H_n = 0.707 \times H_1 \sqrt[3]{\ln\left(\frac{N}{n}\right)} \quad (22)$$

If we take $n = 1$, then we get the probable first maximum wave height

$$H_1 = 39.30 \text{ meters} \quad (23)$$

If we substitute this value in equation (17), then we get the corresponding period

$$T_1 = 24.19 \text{ seconds} \quad (24)$$

III. Conclusion and Discussion

According to incomplete figures, up to the present there have been 36 deep-water wind-wave forecasting models proposed. We have selected the more important and often used 12 for verification and comparison and carried out wind-wave hindcasting for a powerful typhoon that hit Huang Hai, and obtained the following:

- (1) In terms of testing the models using the observation data provided by references 6 and 11, the wave height value calculated according to the model in reference 4 was better than that of the other models, the wave height percentage errors were 35 percent and 32 percent, respectively.
- (2) We carried out a hindcast of waves in a typhoon in Huang Hai, and using the design wave factors of a 50-year return period wave at Xiaomaidao as the norm, then the method in reference 4 gave better wave height values than the other methods, and the best period value was provided by the norms and Wilson IV method simultaneously.
- (3) As for which ratio should be selected for $T_{1/3}/T$ is of general significance and will have to be explored further in the future.
- (4) The values obtained by converting the materials read from the wind velocity record curves of a single station on the seacoast to serve as wind velocity in a wind area have more significance and also can only be determined after systematic exploration in the future.
- (5) As for the examples examined, although among the 12 models selected the method based on reference 4 gave better results, before reaching any final conclusions, more extensive and systematic verification will still be required.

REFERENCES

1. Sverdrup, H.U. and W.H. Munk (1947): WIND, SEA AND SWELL: THEORY OF RELATIONS FOR FORECASTING. U.S. Navy Department, H.O. Pub. 601:1-44.
2. Shandong Haiyang Xueyuan [Shandong College of Oceanology], Haiyangju Diyi Yanjiusuo [First Institute of Oceanography, NBO], Kexueyuan Haiyang Yanjiusuo [Academy of Sciences Institute of Oceanography] (1980): YIGE JISUAN FENGLANG YAOSUDE JINGYAN GUANXI [AN EXPERIMENTAL RELATIONSHIP OF A CALCULATED WIND-WAVE FACTOR], Haigang Shuiwen Zhuanji [Harbor Hydrographic Editors] (Shuiyun Gongcheng Jishu Ziliao) [Water Transport Engineering Technology Materials] 12, 27-29, Renmin Jiaotong Chubanshe.
3. Wen Shengchang [2429 5110 1603] (1960): PUBIAN FENGLANGPU JI QI YINGONG [GENERAL WIND-WAVE SPECTRUM AND ITS APPLICATION], Shandong Haiyang Xueyuan Xuebao [Journal of Shandong College of Oceanology], No 1 (1960) 15-43, or SCIENTIA SINICA, 9(3):377-402.
4. Wang Bingxiang [3076 3521 4382] (1964): FENGLANGPUDE XINGSHIDE ZAI TANTAO [FURTHER EXPLORATIONS INTO THE FORM OF WIND-WAVE SPECTRUM], Haiyang yu Huzhao [Ocean and Lake], 6(1):23-37.
5. Hou Guoben [0186 0948 2609] and others, tr. (1981): HAIYANG JIANZHUYU DONGLIXUE [MARINE CONSTRUCTION DYNAMICS], Ch 4, Haiyang Chubanshe.

6. Bao Qiangsheng [7637 1730 3932], Ye Jia [0673 5521] (1983): JIZHONG ZHUYAO FENGLANG YUBAO FANGFADE YANZHENG YU BIJIAO [VERIFICATION AND COMPARISON OF SEVERAL IMPORTANT WIND-WAVE FORECAST METHODS], Haiyang Ziliao Qingbao [Marine Materials Newsletter], No 2, 1-7.
7. Bishop, C.T. (1983): COMPARISON OF MANUAL WAVE PREDICTION MODELS, J. Waterway, Port, Coastal and Ocean Engineering, 109(1):1-17.
8. Liu, P.C. and M. Asce (1976): APPLICATION OF EMPIRICAL FETCH-LIMITED SPECTRAL FORMULAS TO GREAT LAKES WAVES, Proc. 15th Coastal Eng. Conf., Ch 8, 113-128.
9. Weigel, R.L. (1964): OCEANOGRAPHICAL ENGINEERING, p 205, Fluid Mechanics Series, Prentice Hall, New Jersey.
10. Wilson, B.W. (1965): NUMERICAL PREDICTION OF OCEAN WAVES IN THE NORTH ATLANTIC FOR DECEMBER, 1959 (English). Deutsche Hydrographische Zeitschrift, Jahrgang 18, Heft 3, 114-130.
11. Krylov, Iu.M. (1958): STATISTICHESKAYA TEORIYA I RASCHET MORSKIKH VETOVYKH VOLN [STATISTICAL THEORY AND CALCULATION OF OCEAN WIND-WAVES] Part 2, TrGOIN, No 42, 3-88.
12. Rzhaplinskiy, G.V. (1972): ISSLEDOVANIYE REZHIMA VETROVOGO VOLNENIYA OKEANOV I RASCHETY PARAMETROV VOLN [RESEARCHES ON THE RATE OF OCEAN WIND-WAVES AND CALCULATIONS OF WAVE PARAMETERS], Tr.GOIN, No 111, 3-184.
13. Wang Bingxiang (1962): XINXING FENGLANGPU JI CHI YINGYONG [NEW TYPE WIND-WAVE SPECTRUM AND ITS APPLICATION], Haiyang yu Huzhao, 4(3-4): 142-160.
14. Carter, D.J.T. (1982): PREDICTION OF WAVE HEIGHT AND PERIOD FOR A CONSTANT WIND VELOCITY USING THE JONSWAP RESULTS, Ocean Engng., 9(1): 17-33.
15. Wang Shengchang (1962): HAILANG YUANLI [SEA WAVE PRINCIPLES], Shandong Renmin Chubanshe, 396 pp.
16. Goda Yoshizane (1977): HARO KANSOKU KIROKU SHINISUCHI[?] SHUKI TO HA KO NO TESUGO BUNSEKI NO KAISEKI, Kowan Giken Shiryo, No 272, 1-19.
17. Shandong Haiyangxueyuan Haiyang Shuiwenxiang Xi [Department of Ocean Meteorology, Shandong College of Oceanology] (1964): HAILANG YUBAO FANGFA [METHODS OF SEA WAVE FORECASTING], p 93.
18. Liu Xuexian [0491 1331 0341] and Niu Shikui [3662 0013 1145] (1982): QINGDAO XINGANGQU TAIFENGLANG GELIE FENXI [ANALYSIS OF TYPHOON WINDS IN QINGDAO'S NEW HARBOR], Haiyang Diaochao, No 2, 1982, 23-31.
19. U.S. Army Coastal Engineering Research Center (1973): SHORE PROTECTION MANUAL, Vol 1, U.S. Government Printing Office, Washington, D.C.

20. Zhonghua Renmin Gongheguo Jiaotongbu (1978): GANGKOU GONGCHENG JISHU GUIFAN [TECHNICAL NORMS FOR HARBOR ENGINEERING] (Part 2, Vol 1, Haigang Shuiwen), Renmin Jiaotong Chubanshe, p 138.
21. Bao Qiangsheng, Zhang Rongzhen [1728 2837 3932] (1982): QINGDAO WAIHAI JI JIAOZHOUWAN NEI QIANWAN BOLANG YAOSUDE JISUAN [CALCULATING THE WAVE FACTORS IN THE FOREBAY OF JIAOZHOUWAN AND THE SEAS OFF QINGDAO], Hai'an Gongcheng, No 1, 1982, 46-58.

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METHODS OF FREQUENCY SPECTRUM ESTIMATION OF SEA WATER COMPARED

Qingdao SHANDONG HAIYANG XUEYUAN XUEBAO [JOURNAL OF SHANDONG COLLEGE OF OCEANOLOGY] in Chinese Vol 15 No 3, 15 Sep 85 pp 12-21

[Article by Jiang Decai [5592 1795 2088], Zhang Dacuo [1728 1129 6934], Department of Physical Oceanology and Marine Meteorology, and Gao Xinsheng [7559 2450 3932], Computer Lab: "The Comparison of the Maximum Entropy Method With Conventional One for the Frequency Spectrum Estimation of Sea Wave"; paper received 31 May 1984]

[Text] English Abstract: The principle of the MEM (Maximum Entropy Method) is briefly introduced in this paper. The determination of the length of prediction filter is discussed in the case of the MEM being used for estimating the spectrum of sea wave (wind wave, mixed wave) profile. The quality of the spectrum estimation with MEM and conventional methods is also dealt with under the condition of the same sampling interval and the same sample capacity, it is shown that the MEM has higher resolution, especially for the short series of wave profile records, it is much better than conventional methods.

I. Statement of the Problem

The sea wave power spectrum is a basic characteristic parameter in describing the random processes of sea wave wave surface, it can study the distribution of sea wave energy relative to frequency, as well as study the statistical laws manifested by sea wave wave surface. Thus, it is very important for accurately determining the sea wave frequency spectrum. The correlation and period map methods are the common methods currently used for estimating the sea wave frequency spectrum. They both introduce the subjective will of some hypotheses and certain weight functions. The Maximum Entropy Method (MEM) is a method in which the materials adapt to spectrum estimation. Its window functions are not fixed, it adapts to one frequency and then another, the estimated spectrum values at one frequency are rarely disturbed by variances of other frequencies¹. In 1972, Ulrych² applied Burg³ MEM to estimate frequency spectra, demonstrating the use of short record materials in spectrum estimation, it had high resolution, and was superior to the common correlation and period map methods. This paper applies the MEM to processing random data of sea wave surface and compares it with the traditional methods of estimating sea wave frequency spectra in the search for a more effective method of estimating sea wave spectra.

The MEM has been applied to many geophysical areas with great results. There have not been many application to sea wave frequency spectrum estimation. Takahashi Tomoharu et al.⁴ (1977) used MEM to estimate the frequency spectrum of nonstationary ocean wave surfaces and obtained preliminary results; Tsurutani Ryuichi et al.⁵ (1977) used MEM for frequency estimating of wave surface records of wind-wave trough measurements; Sverre et al.⁶ used MEM to estimate ocean wave surface frequency spectra and discussed the relationship between the spectrum parameters (spectrum moment) and the final prediction error filter length. The work of the above-mentioned scholars showed that using MEM to estimate sea wave frequencies had the advantage of high resolution, but there is still one common problem, i.e., determining the length of the prediction error filter in MEM requires combining specific circumstances of the wave surface (wind-wave, swell, mixed waves). This is because if the filter length is too short it gives a smoothed spectrum, and if it is too long, it also gives secondary peaks formed by false signals. This paper will combine some wave surface records measured by different instruments in China and use the MEM and traditional methods to estimate spectra, then compare the spectral forms, spectral moment, and wave factors; discuss the method for determining the final prediction filter length--the Akaike fixed stage method and capacity ratio fixed stage method to derive a more effective method of estimating sea wave frequency spectra.

II. Basic Principles of MEM

MEM estimates directly from the data a minimum phase prediction error filter, and solves the input power spectrum by using the output power spectrum $P(f)$ of the prediction error filter and the prediction error filter spectrum $|H(f)|^2$

$$S(f) = \frac{P(f)}{|H(f)|^2} \quad (1)$$

MEM is a method of extrapolating the auto-correlation function to the outside of the maximum time lag, its basic idea is to find the entropy maximization at the time of each extrapolated auto-correlation function. It is not restricted by the length itself of stationary random process information, it relies on the predictability of the sampling of both ends for its better resolution, that is, when the entropy is maximized, the auto-correlation is extrapolated.

The relationship of entropy and the stationary Gaussian process spectral density derived according to Smylie¹¹ (1973)

$$H = \frac{1}{4f_N} \int_{-f_N}^{f_N} \log S(f) df + \text{const} \quad (2)$$

in which H is the entropy of the stationary Gaussian process and f_N is Nyquist frequency.

According to the Wiener-Khintchine relationship

$$\int_{-f_N}^{f_N} S(f) Z^k df = R(k\Delta t) \quad (3)$$

in which $Z = \exp(i2\pi f\Delta t)$, Δt is the uniform sampling step length, $R(k\Delta t)$ is the auto-correlation function which has a time lag $(k\Delta t)$. The MEM ends up as a variation problem of solving equation (2) relying on equation (3) as the limiting condition, and the solution to the variation problem is

$$S(f) = \left(\sum_{k=-m}^m \lambda_k Z^k \right)^{-1} \quad (4)$$

in which λ_k is the Lagrange multiplier, determined by equation (3). The ocean power spectrum (frequency spectrum) is a real number and non-negative, thus equation (4) can be rewritten

$$S(f) = \frac{P_m/2f_N}{\left| 1 - \sum_{k=1}^m a_{m,k} Z^k \right|^2} \quad (5)$$

in which $\left(1 - \sum_{k=1}^m a_{m,k} Z^k \right)$ is the minimum phase, P_m is the average output power of the $m+1$ prediction error filter. Rewriting equation (3) as

$$S(f) = \frac{1}{2f_N} \sum_{k=-m}^m R(k\Delta t) Z^{-k} \quad (6)$$

comparing the equal coefficients of Z in equations (5) and (6), and taking into account that $R(k\Delta t)$ is an even function, we get

$$\begin{pmatrix} R_0 R_1 \cdots R_m \\ R_1 R_0 \cdots R_{m-1} \\ \vdots \\ R_m R_{m-1} \cdots R_0 \end{pmatrix} \begin{pmatrix} 1 \\ -a_{m,1} \\ \vdots \\ -a_{m,m} \end{pmatrix} = \begin{pmatrix} P_m \\ 0 \\ \vdots \\ 0 \end{pmatrix} \quad (7)$$

the first matrix on the left is the Toeplitz matrix. The minimum phase filter coefficient $a_{m,k}$ and the average output power P_m are determined by equation (7).

Suppose that the data of an actual sea wave surface event is already known and is expressed as $\zeta_1, \zeta_2, \dots, \zeta_n$, the forward and backward prediction error filters designed by Burg⁷ (1967) are the coefficients $a_{m,k}$ determined by the prediction error square average (output power) minimization. The output power P_1 of the two prediction error filters $(1, a_{1,1})$ wave surface sequence $\zeta_1 (i = 1, 2, \dots, n)$ through the forward and backward prediction error filters

$$P_1 = \frac{1}{2(n-1)} \sum_{i=1}^{n-1} [(\zeta_i - a_{1,1}\zeta_{i+1})^2 + (\zeta_{i+1} - a_{1,1}\zeta_i)^2] \quad (8)$$

in which $(\zeta_i - a_{1,1}\zeta_{i+1})$ is the ζ_i backward prediction error, $(\zeta_{i+1} - a_{1,1}\zeta_i)$ is the ζ_i forward prediction error, and if we wish to minimize the average output power, then $2P_1/2a_{1,1} = 0$, we have

$$a_{1,1} = 2 \sum_{i=1}^n \zeta_i \zeta_{i+1} / \sum_{i=1}^{n-1} (\zeta_i^2 + \zeta_{i+1}^2) \quad (9)$$

From equation (9) we can see that $a_{1,1} < 1$ is the minimum phase prediction error filter.

From equation (7) we get

$$\begin{aligned} R_1 &= a_{1,1} R_0 \\ P_1 &= (1 - a_{1,1}^2) R_0 \end{aligned} \quad (10)$$

$$R_0 = \frac{1}{n} \sum_{i=1}^n \zeta_i^2$$

and applying the Levinson recursion formula

$$a_{m,k} = a_{m-1,k} - a_{m,m} a_{m-1,m-k} \quad (11)$$

which means that the filter coefficient $a_{m,k}$ relies on $a_{m,m}$ and we stipulate $a_{m,0} = -1$, when $k > m$, $a_{m,k} = 0$, the equation (11) is established for all m . $(m+1)$ prediction error filter output power P_m is

$$\begin{aligned} P_m &= \frac{1}{2(n-m)} \sum_{i=1}^{n-m} \left[\left(\sum_{k=0}^m a_{m,k} \zeta_{i+k} \right)^2 + \left(\sum_{k=0}^m a_{m,k} \zeta_{i+m-k} \right)^2 \right] \\ &= \frac{1}{2(n-m)} \sum_{i=1}^{n-m} [(B_{mi} - a_{m,m} B'_{mi})^2 + (B'_{mi} - a_{m,m} B_{mi})^2] \end{aligned} \quad (12)$$

in which

$$B_{mi} = \sum_{k=0}^m a_{m-1,k} \zeta_{i+k} = \sum_{k=0}^m a_{m-1,m-k} \zeta_{i+m-k} \quad (13a)$$

$$B'_{mi} = \sum_{k=0}^m a_{m-1,k} \zeta_{i+m-k} = \sum_{k=0}^m a_{m-1,m-k} \zeta_{i+k} \quad (13b)$$

The $(m+1)$ term prediction error filter's average output power minimization conditions $\partial P_m / \partial a_{m,m} = 0$, expressed by equation (12) have

$$a_{m,m} = \frac{2 \sum_{i=1}^{n-m} B_{mi} B'_{mi}}{\sum_{i=1}^{n-m} (B_{mi}^2 + B_{mi}'^2)} \quad (14)$$

From equations (11) and (13) we obtain the recursion formula of B_{mi} , B'_{mi}

$$B_{mi} = B_{m-1,i} - a_{m-1,m-1} B'_{m-1,i} \quad (15a)$$

$$i = 1, 2, \dots, m$$

$$B'_{mi} = B'_{m-1,i+1} - a_{m-1,m-1} B_{m-1,i+1} \quad (15b)$$

The number groups B_{mi} and B'_{mi} are made up of B_{m-1} and $B'_{m-1,i}$ multiplied by a simple linear operation, the initial value $B_{0i} = B'_{0i} = \zeta_i$ and the value of B_{1i} and B'_{1i} is

$$B_{1i} = \zeta_i \quad (i = 1, 2, \dots, n) \quad (16a)$$

$$B'_{1i} = \zeta_{i+1} \quad (i = 1, 2, \dots, n-1) \quad (16b)$$

Substituting equation (11) in equation (7) we get the recursion formula of P_m

$$P_m = P_{m-1} (1 - a_{m-1,m-1}^2) \quad (17)$$

Using equations (11), (14), (15), (16), and (17) we can directly solve the prediction error filter's coefficient $a_{m,k}$ and the prediction error filter's minimum average output P_m directly from the raw data $\zeta_1, \zeta_2, \dots, \zeta_n$, and estimate the ocean wave spectrum by equation (6). Represented as a circular frequency, equation (6) has

$$S(\omega) = \frac{P_n \Delta t}{2\pi \left| 1 - \sum_{k=1}^n a_{n,k} Z^k \right|^2} \quad (18)$$

the sea wave spectrum is generally expressed as a single-sided spectrum $E(\omega) = 2S(\omega)$. Then the sea wave factors can be calculated through the spectral moment M_k

$$M_k = \int_0^\infty \omega^k E(\omega) d\omega \quad (19)$$

$$\text{the average wave height:} \quad \bar{H} = \sqrt{2\pi M_0} \quad (20)$$

$$\text{the average period:} \quad \bar{T} = 2\pi \sqrt{\frac{M_0}{M_2}} \quad (21)$$

$$\text{the spectral width:} \quad \varepsilon = \sqrt{\frac{M_0 M_4 - M_2^2}{M_0 M_4}} \quad (22)$$

The length $m(<n)$ of the prediction error filter influences the quality of the MEM estimate, determining the filter length m proper is an important issue in MEM estimates. We used the Akaike (1969a)⁸, 1969b⁹ and 1970¹⁰ fixed stage method and capacity ratio fixed stage method to determine the prediction error filter length for the different kinds of information of wind-wave, swell, and mixed wave. In this paper, the Akaike step determining method took the first very small value of the minimal final prediction error (EPE) and for centralized sampling we had

$$(EPE)_m = \frac{N+m+1}{N-(m+1)} P_m \quad (23)$$

in which N is the sample capacity, m is the prediction error filter length. In the capacity ratio fixed stage method, we took

$$m = N/20 \quad (24)$$

III. Comparison of Spectral Estimates

We used different information materials (wind-wave, mixed wave) observed by different wave measuring instruments (water pressure type, gravity type, ultrasonic type). We applied auto-correlation, period mapping, and MEM for spectrum estimating and in MEM also took the prediction error filter length m determined by equations (23) and (24).

1. Comparison of Methods for Spectrum Estimating

Figures 1, 2, and 3 give the wind-wave materials observed by the water pressure wave measuring instruments, all used a sampling step length of $\Delta t = 0.375$ second, and the spectrum curve of the various methods of estimating the spectrum where sample capacities were $N = 2048, 1024$, and 512 , respectively. In the figures, COV represents the auto-correlation function method, FFT represents the period mapping method, MES represents MEM. In the figures, in the conventional methods, k represents the free degrees, in MEM it represents prediction error filter length k , Akaike's fixed stage method is determined by the self selected first extremely small value, therefore the value k is not clearly noted. In the figures, the solid line is the spectrum curve of Akaike's fixed stage method MEM spectrum estimate. From the three figures one can see that the MEM extreme value is higher than the extreme value given by the conventional spectrum estimation, and that the curve is smooth, indicating that the spectrum deviation is small. However, in Figure 1, when $N = 2048$, the extreme value of the Akaike fixed stage spectrum estimation is lower than the spectrum value estimated by the capacity ratio stage fixed at $N/20$ method. From the figures, it can be seen that MEM spectrum estimating is generally superior to the conventional method, the application of Akaike's method of determining m by the criterion of the first extremely small value is feasible in wind-wave information, because the two methods of determining m in MEM, when capacity N is large, the capacity determinant ratio method displays better spectrum extreme values, but the high frequency spectrum values are not as smooth as the Akaike fixed stage method. From Figures 1 to 3, when the sample capacity N shrinks to $N/2$ or

$N/4$, the spectrum values estimated by MEM have a spectrum curve similar to N , indicated the superiority of MEM for short series spectrum estimating.

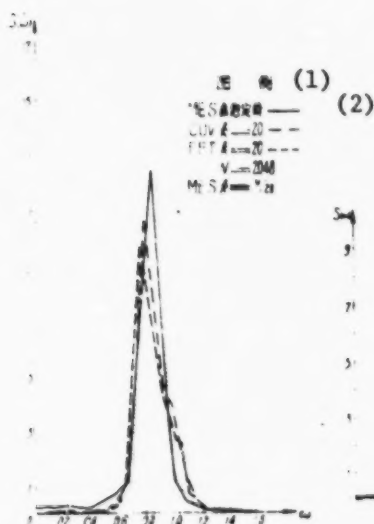


Figure 1. Spectrum Estimate (water pressure wave measurement record, $N = 2048$)

Key:

1. Legend
2. Akaike fixed stage

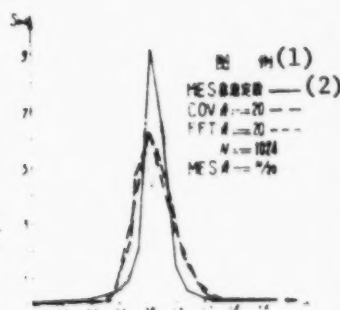


Figure 2. Spectrum Estimate (water pressure wave measurement record, $N = 1024$)

Key:

1. Legend
2. Akaike fixed stage

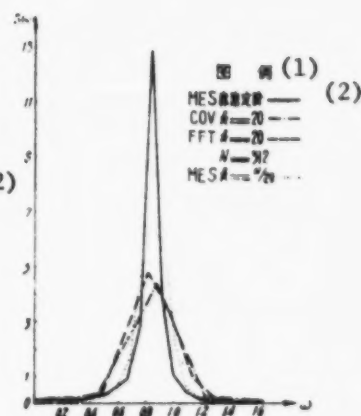


Figure 3. Spectrum Estimate (water pressure wave measurement record, $N = 512$)

Key:

1. Legend
2. Akaike fixed stage

Figures 4, 5, and 6 give the wind-wave materials observed by ultrasonic wave measuring device. The step length for all samples was $\Delta t = 0.75$ seconds, and the spectrum curve of the various methods of estimating the spectrum where sample capacities were $N = 1024$, 512 , and 256 , respectively. The solid line in the figure represents spectrum curve of the MEM estimate with capacity ratio stage fixed at $N/20$. Discussing the quality of the spectrum estimate from the angle of the spectrum's piandu [0252 1653 bias?] and deviation, we see that the extreme value of the spectrum estimated by the capacity fixed ratio method is the highest, but the fact that degree of freedom $k = 20$ in the high frequency spectrum value curve and the auto-correlation function method is rather uniform means that the capacity fixed ratio $N/20$ for estimating the spectrum values is rather good. The broken line in the figures represents the spectrum curve of the Akaike fixed stage MEM, the high frequency partial spectrum value deviation is small, and it is also superior to the spectrum curve of the estimate of degree of freedom $k = 20$ of the auto-correlation method. Therefore, Akaike

fixed stage MEM estimated spectrum is better. When the sample capacity is reduced by doubling [chengbei 2052 0223], the MEM spectrum estimate give an excellent spectrum curve.

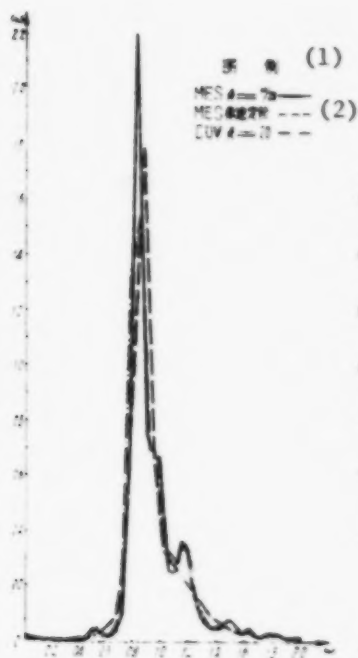


Figure 4. Spectrum Estimate (ultrasonic wave measurement record, $N = 1024$)

Key:

1. Legend
2. Akaike fixed stage

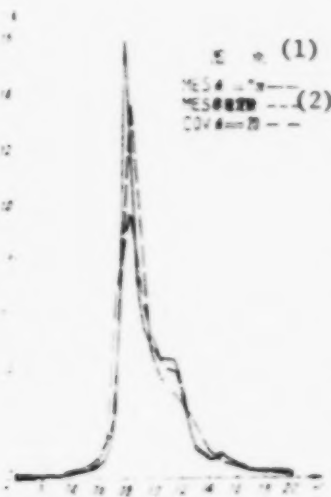


Figure 5. Spectrum Estimate (ultrasonic wave measurement record, $N = 512$)

Key:

1. Legend
2. Akaike fixed stage

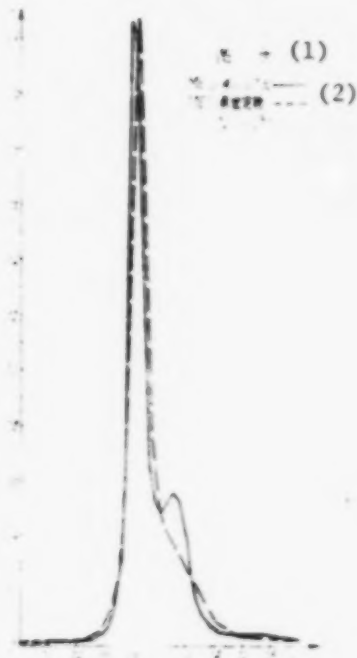


Figure 6. Spectrum Estimate (ultrasonic wave measurement record, $N = 256$)

Key:

1. Legend
2. Akaike fixed stage

Figures 7, 8, and 9 give the mixed wave materials observed by the gravity wave measuring device. The spectrum curve of the various methods of estimating the spectrum where the step length for all samples was $\Delta t = 0.75$ seconds, and where sample capacities were $N = 1024$, 512 , and 256 , respectively. The solid line in the figure representing the spectrum curve of the MEM estimate at a capacity ratio fixed stage of $N/20$, is superior to the spectrum curve of the conventional method and the Akaike fixed stage MEM. The MEM spectrum curve given by the Akaike first extremely small value discrimination method is a spectrum that tends to be smoothed, and the spectrum extreme value is lower than the conventional method, the corresponding frequency position difference for the spectrum extreme value is also greater. This indicates that the prediction error filter length m determined

by the Akaike first extremely small discrimination method is suited to spectrum estimates of the pure Gaussian processes, and for mixed wave information is given a smoothed spectrum.

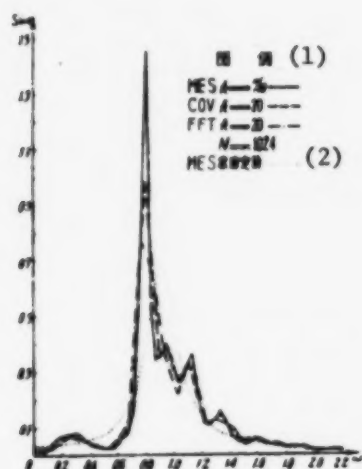


Figure 7. Spectrum Estimate (gravity wave measurement record, $N = 1024$)

Key:

1. Legend
2. Akaike fixed stage

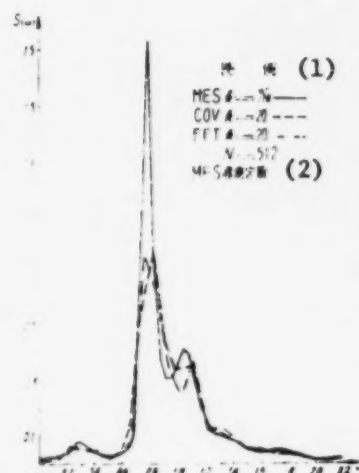


Figure 8. Spectrum Estimate (gravity wave measurement record, $N = 512$)

Key:

1. Legend
2. Akaike fixed stage

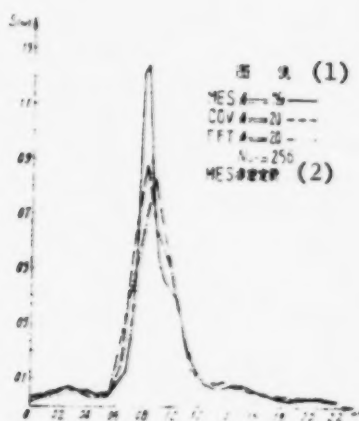


Figure 9. Spectrum Estimate (gravity wave measurement record, $N = 256$)

Key:

1. Legend
2. Akaike fixed stage

2. Comparison of Spectrum Moment and Wave Factors

Table 1 gives the spectrum moment M_0 , M_2 , M_4 , spectrum width and average wave height, and average period of the wind-wave materials observed by the pressure wave measuring device. In the first column, MESA represents the calculated spectrum moment and wave factors by the Akaike fixed stage MEM estimated spectrum, MESB represents the capacity ratio $N/20$ fixed state MEM, COV is the auto-correlation function method, FFT is the period mapping method. From Table 1 it can be seen that sample capacity $N = 2048, 1024, 512$ correspond to the spectrum moments M_0 , M_2 and average wave height $\bar{H}$, average period $\bar{T}$, and spectrum width calculated by the various methods are all fairly close, only the relative changes in M_4 are larger. However, for actual application, the above described parameters are sufficiently precise, therefore the spectrum moments and wave factors estimated by the various methods have practical significance. The wind-wave materials measured by the ultrasonic wave measuring device also produced similar results, and they will not be tabulated and explained here.

Table 1. Comparison of Spectral Moment and Wave Factors (wind-wave materials)

(1) 方法	(2) 容量 N	M_0	M_2	M_4	ϵ	$\bar{H}$	$\bar{T}$
MESA	2048	2.298	2.017	16.172	0.944	3.800	6.71
MESB	2048	2.377	2.081	16.280	0.942	3.861	6.71
COV	2048	2.444	2.101	13.905	0.933	3.918	6.78
FFT	2048	2.407	2.094	15.404	0.939	3.889	6.74
MESA	1024	1.890	1.750	10.267	0.937	3.450	6.53
MESB	1024	2.070	1.878	13.308	0.934	3.607	6.60
COV	1024	2.040	1.810	11.043	0.924	3.581	6.67
FFT	1024	1.998	1.808	13.044	0.935	3.540	6.61
MESA	512	2.060	1.840	11.410	0.937	3.60	6.65
MESB	512	2.004	1.808	13.306	0.937	3.55	6.62
COV	512	2.020	1.750	10.450	0.924	3.56	6.75
FFT	512	1.919	1.712	12.589	0.937	3.47	6.65

Key:

1. Method
2. Capacity N

Table 2 gives the mixed wave materials measured by the gravity wave measuring device, and applies the spectrum moment, spectrum width and wave factors calculated for the estimated spectrum by the various methods. From Table 2 it can be seen that the statistical values found for the spectra estimated by the various methods are all very close, and have practical significance. The statistical values (spectrum moment and wave factors) of Tables 1 and 2 explain that whether wind-wave or mixed wave, although there are great differences in the spectrum curves estimated by the various methods, the statistical values are very close and can be used for general engineering.

Table 2. Comparison of Spectral Moment and Wind Factors (mixed waves)

(1)方法	(2)容量N	M_0	M_2	M_4	ϵ	$\bar{H}$	$\bar{T}$
MESA	1024	0.321	0.450	1.912	0.818	1.419	5.30
MESB	1024	0.320	0.449	1.901	0.813	1.418	5.30
COV	1024	0.312	0.445	1.885	0.817	1.412	5.30
FFT	1024	0.310	0.434	1.790	0.813	1.396	5.31
MESA	512	0.336	0.457	1.898	0.820	1.453	5.39
MESB	512	0.335	0.456	1.887	0.819	1.451	5.39
COV	512	0.329	0.448	1.845	0.818	1.437	5.38
FFT	512	0.301	0.421	1.742	0.914	1.376	5.31
MESA	256	0.385	0.564	2.855	0.843	1.555	5.19
MESB	256	0.385	0.564	2.865	0.843	1.555	5.19
COV	256	0.370	0.547	2.752	0.841	1.525	5.17
FFT	256	0.344	0.515	2.532	0.841	1.471	5.19

Key:

1. Method
2. Capacity N

IV. Conclusion

1. For wind-wave materials measured by water pressure wave measuring devices, the spectrum curve estimated using the Akaike first very small value fixed stage MEM is superior to the spectrum curve estimated by the conventional method and the capacity ratio $N/20$ fixed stage MEM.

2. For the wind-wave materials measured by the ultrasonic wave measuring device, when the sample capacity $N \geq 512$, the spectrum values estimated using the capacity ratio $N/20$ fixed stage MEM are better, and it is superior to the conventional method and the Akaike fixed stage MEM, when $N = 256$, the spectrum values estimated by the two fixed stage MEM are close. This indicates that when the ultrasonic wave measuring records which directly reflect the wind-wave information are used to estimate the spectrum, the smoother spectrum produced by the Akaike fixed stage MEM has a resolution lower than the capacity ratio $N/20$ fixed stage MEM and is superior to conventional method of estimating spectra. For convenience of use, we can use the Akaike fixed stage MEM.

3. For mixed waves, the spectrum estimated by the Akaike fixed stage MEM gives a smoothed spectrum, resolution is lower than or equal to the conventional spectrum estimate, but the capacity ratio $N/20$ fixed state MEM estimated spectrum displays better resolution and is superior to spectrum values estimated by conventional methods. Therefore, when the Akaike fixed stage MEM is used to estimate the spectra of mixed wave materials, it is still necessary to improve the discrimination standards for determining the prediction error filter length. Otherwise, carrying out test

calculations using the capacity ratio fixed stage method is like trials using the conventional method with different degrees of freedom to discriminate the optimum quality spectrum estimate.

4. Although in using the various methods to carry out spectrum estimates on wind-wave (6 groups) and mixed wave (4 groups) wave surface records measured by different devices there are differences in the spectrum structures and difference deviations and biases are revealed, the statistical parameters--spectrum moment, spectrum width, average wave height, average period--through calculations of the estimated spectrum are all fairly close and all have practical significance.

5. For short sample capacities, the Akaike fixed stage MEM estimated spectrum exhibited that it is even more superior to the conventional spectrum estimating method.

REFERENCES

1. J.S. Goerss and A.J. Kosicelny, 1977: FIFTH CONFERENCE ON PROBABILITY AND STATISTICS IN ATMOSPHERIC SCIENCE, 1977, pp 297-302.
2. Ulrych, T.J., 1972: MAXIMUM ENTROPY POWER SPECTRUM OF TRUNCATED SINUSOIDS, J. Geophys. Res., 77, 1396-1480.
3. Burg, J.P., 1968: A NEW ANALYSIS TECHNIQUE FOR TIME SERIES DATA. Paper presented at Advanced Study Institute of Signal Processing, NATO, Enschede, Netherlands.
4. Takahashi Tomoharu [?], 1977: CONSIDERATION ON WAVE SPECTRA ESTIMATION BY MEM (MAXIMUM ENTROPY METHOD), (1) Kowan Giken Shiryo, No 273.
5. Tsurutani Ryuichi, (1977): CONSIDERATION ON WAVE SPECTRA ESTIMATION BY MEM (MAXIMUM ENTROPY METHOD), (2) Kowan Giken Shiryo, No 274.
6. Sverre Holm and Jensm Hovem, 1979: ESTIMATION OF SCALAR OCEAN WAVE SPECTRA BY THE MAXIMUM ENTROPY METHOD, IEEE J of Ocean Engineering, 1979.
7. Bury, J.P., 1967: MAXIMUM ENTROPY SPECTRAL ANALYSIS, Paper presented at the 37th Annual International Meeting, Soc. of Explor. Geophys., Oklahoma City, Okla.
8. Akaike, H., 1969a: FITTING AUTOGRESSIVE MODELS FOR PREDICTION, Ann. Inst. Statist. Math. 21.
9. Akaike, H., 1970: STATISTICAL PREDICTOR IDENTIFICATION, Ann. Inst. Statist. Math., 22.
10. Akaike, H., 1969b: POWER SPECTRUM ESTIMATION THROUGH AUTOREGRESSIVE MODEL FITTING, Ann. Inst. Statist. Math., 21.

11. Van den Bos, A., 1971: ALTERNATIVE INTERPRETATION OF MAXIMUM ENTROPY SPECTRAL ANALYSIS, IEEE Trans. on Inform. Theory, IT-17, 4:493-494.

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PHYSICAL SCIENCES

PHASE SPEED OF WIND-WAVE COMPONENT STUDIED

Qingdao SHANDONG HAIYANG XUEYUAN XUEBAO [JOURNAL OF SHANDONG COLLEGE OF OCEANOLOGY] in Chinese Vol 15 No 3, 15 Sep 85 pp 33-39

[Article by Xu Delun [1776 1795 0243], Department of Physical Oceanology and Marine Meteorology: "Measurements of Phase Speed of Wind-Wave Component and Interpretation of Their Result"; article received 30 June 1984]

[Text] English Abstract: Measurements of phase speed of wind-wave component were made by cross-spectrum method, separation distance between the two probes for measuring surface elevations being 2 cm.

The measured data indicate that the relationship between phase speed and frequency varies with wind speed and water depth. For one extreme condition, low wind and deep water, it obeys basically the classical linear dispersion relation. For the other extreme condition, high wind and shallow water, the components are non-dispersive, all traveling with the same speed as the component with spectrum-peak frequency. For medium conditions, the dispersion relations have some forms between the two extreme cases.

The measured result can be interpreted on the basis of a refined spectral model, which consists of the contributions of both dispersive and non-dispersive wave with the effect of drift current included. At low wind and in deep water, the wave field is of low nonlinearity: free waves are dominant and, hence, the wave components are dispersive and obey the classical dispersion relation. At high wind and in shallow water, the wave field has high nonlinearity. In this case, forced waves dominate over free waves and the wave components appear to be non-dispersive.

I. Introduction

Linear wave spectrum theory holds that wind-waves are the result of the linear superposition of simple waves of many frequencies, unequal oscillation and confused phase. According to this theory, the phase velocity of wind-waves should obey linear wave dispersion relation $c = g/n$ (n is circular frequency, g is gravitational acceleration). Does this theory really conform to a large degree to the actual wind-wave conditions? The answer relies on accurate measurements of wind-wave phase velocity. Ramamonjiarisoa

(1974)¹ of the Marseille Laboratory in France used the cross-spectrum method to measure and obtain data. This data indicated that only the wave component of the wind-wave whose frequency was near the spectrum peak frequency obeyed the linear dispersion relation, wave components with higher frequencies were non-dispersive, and both were propagated at almost identical phase velocities.

The measurement data of Ramamonjiarisoa (1974) attracted wide attention. Some researchers (Huang, 1981; Dudis, 1981, et al.) expressed doubts about the measurement method of this data. Through a strict theoretical analysis, Huang (1981) pointed out that the distance between the two probes which Ramamonjiarisoa (1974) used in measuring wave surface height was too great (10 cm) and thus he could not measure the phase velocity of wave components at higher frequencies. In addition, Ramamonjiarisoa's measurement data was only obtained at medium velocity, and lacks data at low wind speed and higher wind speeds.

This paper first of all reports the laboratory measurement results. These data were still obtained using the cross-spectrum method, but the distance between the probes was reduced to 2 cm, and the results include various situations such as from low wind speed (3 m/sec) to higher wind speeds (14 m/sec) and shallow water. Finally, there is a theoretical interpretation of the measured results.

II. Cross-Spectrum Method

The definition of cross-spectrum $\Psi(\vec{r}, n)$ is

$$\Psi(\vec{r}, n) = \int_{\vec{R}} \phi(\vec{k}, n) e^{i\vec{k} \cdot \vec{r}} d\vec{R} \quad (1)$$

in which, $\phi(\vec{R}, n)$ is the wave number-frequency spectrum, $\vec{k}$ is the vector wave number, n is the circular frequency, $\vec{r}$ is the vector distance between the two measuring probes.

The phase spectrum function can be found from the cross-spectrum

$$\theta(\vec{r}, n) = \tan^{-1} \left[\frac{Q(\vec{r}, n)}{C_0(\vec{r}, n)} \right] \quad (2)$$

in which C_0 and Q are the real parts (equal phase spectrum) and false parts (out-of-phase spectrum), of the cross-spectrum $\Psi(\vec{r}, n)$, i.e.,

$$C_0(\vec{r}, n) = \int_{\vec{k}} \cos(\vec{k} \cdot \vec{r}) \phi(\vec{k}, n) d\vec{k}$$

and

$$Q(\vec{r}, n) = \int_{\vec{k}} \sin(\vec{k} \cdot \vec{r}) \phi(\vec{k}, n) d\vec{k}$$

If the wind-wave is propagated only in the single direction $\vec{r}$, then the phase velocity spectrum of the wind-wave component can be found from the wei [0143 positional?] phase spectrum

$$c(n) = \frac{rn}{\theta(r, n)} \quad (3)$$

This equation is the one used by Yefimov et al. (1972)² and Ramamonjiarisoa et al. (1979)³ to calculate the wind-wave component phase velocity.

After stricter theoretical deductions, Huang (1981)⁴ stated: The suitable conditions for equation (3) only limited to wave field is unidirectional, and the distance between the two probes must be small enough to satisfy the condition

$$|\vec{k}, \vec{r}| \ll 1 \quad (4)$$

III. Experiment and Results

Experiments were carried out in a wind-wave-flow experimental trough at the University of Delaware in the United States. The trough length was 44 meters, 1 meter wide and the water depth at the time of the experiment was 0.75 meters. Two capacitance wave measuring devices were used for measurement of the wave surface height. The distance between the two probes was 2 centimeters. Four groups of measurement data were obtained in all. Three of the groups were taken in a wind area of 30 meters, at wind speeds of 3, 8, and 14 m/sec, respectively; the other group was taken in shallow water on a slope at the end of the trough, wind speed was 12 m/sec. The recording time of each group of data was 304 seconds. The sectional direct method was used for estimating the frequency spectrum, each 304 second record was broken up into 38 sections. The sampling rate was 64 Hz, there were 19456 data points in each group, and 512 data points in each section. The frequency ($f = \frac{n}{2\pi}$) resolution of the cross-spectrum used for estimate results was 0.125 Hz, and its degree of freedom was 76.

Since the water trough was narrow, we could more or less accept that the wave field measured was unidirectional. Probe distances of 2 cm make the wave components below a frequency of 5 Hz satisfy condition (4) very well. This means that the results of the measurement are effective for wave components of below a frequency of 5 Hz. The phase velocity relative frequency f points calculated according to equations (2) and (3) from the wave surface records are plotted in Figures 1, 2, and 3. For ease of comparison, two separate curves are also plotted in these figures. The solid line is the theoretical curve calculated from the linear wave dispersion relation (including the influence of surface tension T).

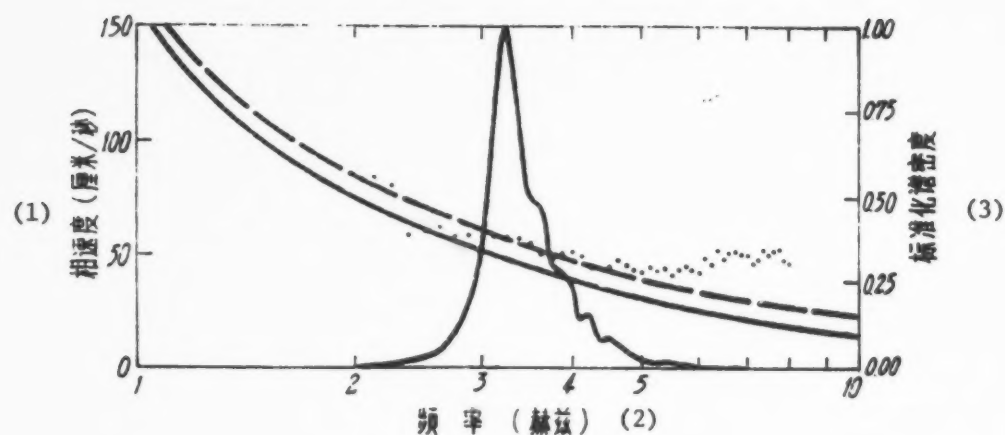


Figure 1. Relationship of Frequency and Phase Velocity of Wind-Wave Component at Low Wind Speed (Wind speed is 3 m/sec, water depth is 75 cm)

Key: 1. Phase velocity (cm/sec)
2. Frequency (Hz)
3. Standardized spectrum density

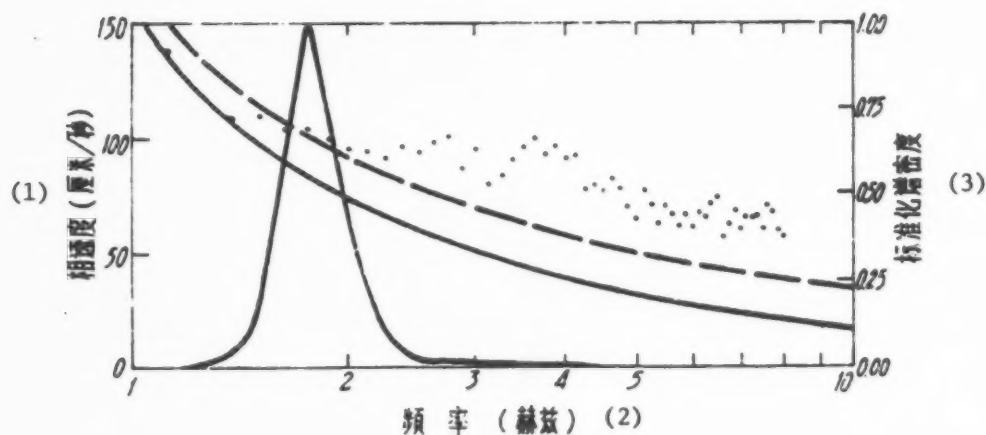


Figure 2. Relationship of Frequency and Phase Velocity of Wind-Wave Component at Medium Wind Speed (Wind speed is 8 m/sec, water depth is 75 cm)

Key: 1. Phase velocity (cm/sec)
2. Frequency (Hz)
3. Standardized spectrum density

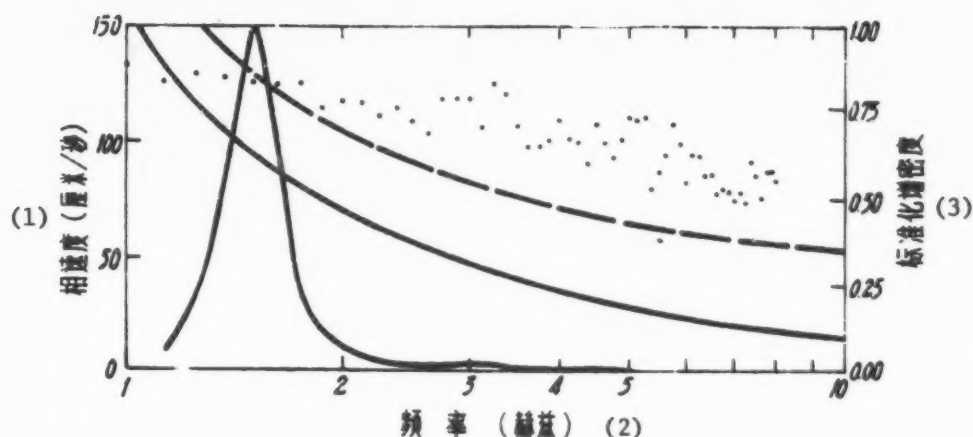


Figure 3. Relationship of Frequency and Phase Velocity of Wind-Wave Component at Higher Wind Speed (Wind speed is 14 m/sec, water depth is 75 cm)

Key:

1. Phase velocity (cm/sec)
2. Frequency (Hz)
3. Standardized spectrum density

$$c = \sqrt{\frac{g\lambda}{2\pi} \frac{\rho - \rho'}{\rho + \rho'} + \frac{2\pi T}{\lambda(\rho + \rho')}} \quad (5)$$

(in which ρ and ρ' are water and air density, respectively and λ is wave length); the broken line was obtained from the right side of equation (5) plus the phase velocity c_u which increases because of wind drift, i.e., from the equation

$$c' = \sqrt{\frac{g\lambda}{2\pi} \frac{\rho - \rho'}{\rho + \rho'} + \frac{2\pi T}{\lambda(\rho + \rho')}} + c_u \quad (6)$$

In the laboratory, the drift produced by the wind had a very clear impact on wind-wave velocity. We do not yet have a theoretical method to calculate this impact, nor do we have actual measurement results which can be used. For ease of comparison, we use approximations [?], we view the differences at the spectral peak frequencies of velocity measured by the cross-spectrum method and the velocity provided by the linear dispersion relation as wave component phase velocity of value c_u which increases because of wind drift.

From Figures 1-3 it can be clearly seen that at different wind speeds, the tendency of wind-wave component phase velocity which was measured changes with frequency are slightly different. At low wind speeds (3 m/sec), the measurement data of frequencies below 5 Hz fits fairly well with the theoretical curve. At medium wind speeds (8 m/sec), beginning with a frequency of 2.3 Hz, the measurement data systematically deviates from the theoretical curve. This is generally the same as the results measured by

Ramamonjiarisoa. As the wind speed increases, the starting point where the measurement data deviates from the theoretical curve shifts toward lower frequencies. At 14 m/sec wind speed, it has already shifted to approximately 2 Hz in the vicinity of the spectrum peak.

In the experiment we also measured the shallow water situation. The results are displayed in Figure 4. The measurement points were on the slope at the end of the trough, the water depth at the place of measurement was 7.5 cm and the wind speed was 12 m/sec. It is very clear that under these conditions, beginning with the spectrum peak frequency (1.3 Hz), the phase velocity of the wind-wave component was almost maintained as a constant, and the wave component was non-dispersive.

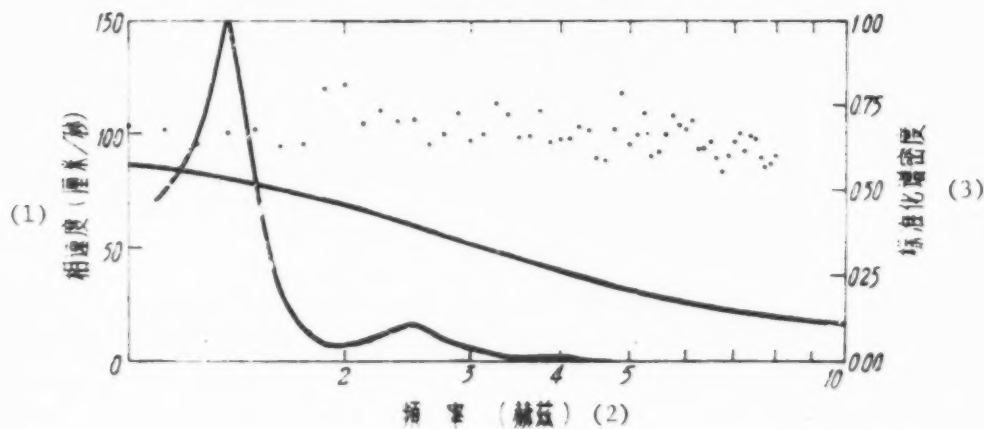


Figure 4. Relationship of Frequency and Phase Velocity of Wind-Wave Component in Shallow Water (Wind speed is 12 m/sec, water depth is 7.5 cm)

Key:

1. Phase velocity (cm/sec)
2. Frequency (Hz)
3. Standardized spectrum density

Summing up the above, the tendency of wind-wave component phase velocity relative to changes in frequency is very closely related to the wind wave field situation, and does not uniformly obey the linear dispersion relation.

IV. Interpretation of Results

Recent wave spectrum theory⁵ holds that: the wind-wave spectrum is made up of non-dispersive waves (also called forced waves) and dispersive waves (also called free waves). Referring to the model proposed by Dudis (1981)⁶ and taking into account the effect of wind drift, we proposed the following frequency-wave number spectrum model for unidirectional wave fields:

$$\phi(\vec{k}, n) = \phi_N(n) \delta\left(k - \frac{n}{c_N + c_u}\right) + \phi_D(n) \delta\left(k - \frac{n^2}{g + nc_u}\right) \quad (7)$$

in which ϕ_N and ϕ_D represent, respectively, the contributions of non-dispersive and dispersive waves to the frequency spectrum, c_N is the phase velocity of the non-dispersive waves, c_u is the phase velocity of the wave component increased due to wind drift, and δ represents the Dirac delta function.

Substituting equation (8) in equation (2) we get

$$\tan\theta(n) = \frac{\mu(n) \sin \frac{rn}{c_N + c_u} + \sin \frac{rn^2}{g + c_u n}}{\mu(n) \cos \frac{rn}{c_N + c_u} + \cos \frac{rn^2}{g + c_u n}} \quad (8)$$

in which

$$\mu(n) = \frac{\phi_N(n)}{\phi_D(n)} \quad (9)$$

is the ratio of the contributions to the frequency spectrum of non-dispersive waves and dispersive waves. In a research report, Xu et al. (1984)⁷ solved $\mu(n)$ as a function of effective wave surface slope $\zeta =$

$\frac{(\zeta^2)^{1/2}}{\lambda_0}$ (in which, $(\zeta^2)^{1/2}$ is the root-mean-square surface height, λ_0 is the

wave length of a wave component which has the spectrum peak frequency) and the effective depth (n is the water depth). For deep water and low wind speed situation, $\mu(n) \ll 1$, thus, equation (8) is simplified to

$$\theta(n) = \frac{rn^2}{g + c_u n} \quad (10)$$

Substituting equation (10) in equation (3) we get

$$c(n) = \frac{g}{n} + c_u \quad (11)$$

Clearly, under low speed conditions, except for the added term c_u produced by wind drift, the phase velocity of the wave component fits to the linear dispersion relation equation. For shallow water and high wind speed, $\mu(n) \gg 1$, thus, equation (8) is simplified to

$$\theta(n) = \frac{rn}{c_N + c_u} \quad (13)$$

[sic]

Substituting this equation in equation (3), we have

$$c(n) = c_N + c_u \quad (14)$$

Clearly, under these conditions, the wave field is non-dispersive, and the wave components are propagated as constant velocity.

The above are two extreme situations. The others are ordinary situations displayed in Figures 2 and 3. The wave component phase velocity relative to changes in frequency takes a form between equation (11) and equation (12) [as published]. The results measured by Ramamonjiarisoa under medium wind speed appears to be one type belonging to the above discussed ordinary situation.

V. Conclusion

The above measurement results and the theoretical interpretation show that the wind-wave component's dispersion relation is rather sensitive to nonlinearity of the wave field. In shallow water and at low wind speed, the wave field has lower nonlinearity, the wave component's phase velocity basically obeys the linear dispersion relation (except for the influence of wind drift). As wind speed increases, the wave surface becomes steeper, the wave field's nonlinearity becomes higher, the wave component phase velocity at the higher frequency deviates from the linear dispersion relation. In shallow water at higher wind speeds, the wave field has powerful nonlinearity. At such times, non-dispersive waves play the dominant role, and thus the wave field is basically non-dispersive, and all the wave components are propagated at nearly the same velocity.

The above measurement results and theoretical analysis also show that when computing wind-wave wave component phase velocity, drift produced by the wind should be taken into consideration, at least this should be the case for laboratory wind-waves.

REFERENCES

1. Ramamonjiarisoa, A., 1974: CONTRIBUTION A L'ETUDE DE LA STRUCTURE STATISTIQUE ET DES MECHANISMES DE GENERATION DES VAGUES DE VENT. Thesis de Doctorat d'etat. Inst. de Mec. Statist. de la Turb., Univ. de Provence, France.
2. Yefimov, V.V., Yu. P. Solov'yev and G.N. Khristoforov, 1972: OBSERVATIONAL DETERMINATION OF THE PHASE VELOCITIES OF SPECTRAL COMPONENTS OF WIND WAVES, *Izv. Atmos. Oceanic Phys.*, 8, 435-446.
3. Ramamonjiarisoa, A. and E. Mollo-Christensen, 1979: MODULATION CHARACTERISTICS OF SEA SURFACE WAVES, *J. Geophys. Res.*, 84, 7769-7775.
4. Huang, N.E., 1981: COMMENT ON MODULATION CHARACTERISTICS OF SEA SURFACE WAVES' TU A. RAMAMONJIARISOA AND E. MOLLO-CHRISTENSEN, *J. Geophys. Res.*, 86, 2073-2075.

5. Macuda, A., Y.Y. Kuo, and H. Mitsuyasu, 1979: ON THE DISPERSION RELATION OF RANDOM GRAVITY WAVES, PART 1, THEORETICAL FRAMEWORK, J. Fluid Mech., 92, 717-730.
6. Dudis, J.J., 1981: INTERPRETATION OF PHASE VELOCITY MEASUREMENTS OF WIND-GENERATED SURFACE WAVES, J. Fluid Mech., 113, 241-249.
7. Xu Delun, Joe Wang, and Jin Wu, 1984: EQUILIBRIUM SPECTRUM OF WIND-GENERATED WAVES FROM DEEP TO SHALLOW WATER, Technical Report No JW-24, Air-Sea Interaction Laboratory, College of Marine Studies, University of Delaware.

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CHINESE LANGUAGE MICROCOMPUTER DESCRIBED

Beijing DIANZI KEXUE JISHU [ELECTRONICS SCIENCE AND TECHNOLOGY] in Chinese
Vol 16 No 5, 10 May 86 pp 10-11

[Article by Chen Shiming [7115 0013 6900], Academy of Sciences, Guangdong:
"The Characteristics and Use of the LX-80A Chinese Language Computer"]

[Text] The LX-80A associative Chinese character graphics microcomputer system (hereafter, Chinese language computer) was successfully developed by the Institute of Computing Technology of the Chinese Academy of Sciences, and is currently in production by units such as the experimental factory of the Guangdong Academy of Sciences. Its characteristics and methods of use are as follows:

Multiple Chinese Character Input Methods

Chinese character input for the LX-80A Chinese language computer is easy to learn and is broadly adaptable.

1. The "interactive" Chinese character input method.

This method is coded according to the stroke shapes of Chinese characters, so it is also called "stroke coded." There are 40,000-50,000 Chinese characters, more than 6,000 of which are in common use, and stroke coding can classify the stroke components of the character radical into 26 basic shapes. There are 6 basic strokes (一、丨、ノ、㇏、フ、㇏) . 7 common radicals (土、木、マ、艹、人、扌、口),

12 stroke combinations, and 1 independent character-stroke shape. The code of each stroke uses the keyboard position of an English letter, and the name of each stroke uses the Chinese character command that may be seen at the left of Figure 1. For example, the stroke shape "艹" is called "grass and the corresponding key is the letter "Q."



Figure 1

The input method used by the LX-80A system is called "visual keyboard input." At the bottom of the screen of the display device there is a three line prompt area, where after power up, the 26 stroke shapes in Figure 1 and their corresponding English letters are all displayed in the prompt lines. To enter a particular stroke, just press the corresponding letter key. To enter the "grass" radical, press "Q."

Using stroke shape coding to enter Chinese characters is largely the same as our habits in writing them. The rule in writing out strokes is that it proceeds from left to right, from top to bottom, from the outside to the inside, etc. The stroke shape coding method of the LX-80A system uses the first stroke and the second stroke. Those characters that use only the first stroke may then be found, but the majority of characters will need the second stroke shape before they can be found. For some words that are not divisible, called independent words, as for example "户", after the first stroke shape press the 'L' key (the independent word key), which will then locate the word. The distinction between the first stroke shape and the second is indicated by the letter appearing at the left in the prompt area. We will now use the entry of the 5 characters of "Chinese Academy of Sciences" 中国科学院 as an example to illustrate this method. The first stroke shape of these 5 characters is as in the written example in Figure 2.

中国科学院

Figure 2

The first stroke of 'zhong' is 'l,' so push the 'S' key. At this time, 26 characters having 'l' as their first stroke will appear in the prompt area of the screen (the 26 characters in the prompt area have differing stroke counts and will not necessarily be the same each time), and when the character 'zhong' appears in the position of the letter 'M,' press lower case 'M' to enter the character 'zhong' in the text. Similarly, for the character 'guo' press 'N,' then enter the lower case 'p,' for the character 'ke' press 'F,' for 'xue' press 'D,' and for 'yuan' press 'B,' after which you must also press 'D' for the second stroke shape before 'yuan' will appear on the screen.

Because we are using 26 stroke shapes to find all Chinese characters, this requires a greater representation to include all stroke shapes in Chinese characters. For example, the stroke shape "ㄣ" represents both "𠂇" and also "ㄣ", "巨", "局", "尽" etc., for the left part of these characters all have the shape of "ㄣ".

When using stroke shape coding to enter the character radicals or the radical components, the prompt area of the computer screen will display the Chinese characters one needs, and will tell you which key should be pressed next to enter a character. This method is called "interactive" entry.

2. The romanization entry method.

Similarly to the "interactive" entry method, use the romanization key for the LX-80A system to accomplish the task of character entry by pressing the keys that represent the initials and finals and the corresponding material in the prompt area of the screen.

3. The "arbitrary selection coding" entry method.

As of this moment, there are hundreds of different Chinese character input methods, and the design of the LX-80A has taken into consideration coding schemes with which the user may already be familiar, as for example the telegraphic code, the Cang Jie code, or the four-corner code, and the user may select one among them as an input method for the LX-80A system. After entering the telegraphic code, press the "arbitrary selection" function key and the computer will be placed in the "arbitrary selection coding" state (i.e., telegraphic code). At this time, characters may be entered with telegraphic codes.

The LX-80A system provides users with software for "automatic generation of an arbitrary selection coded dictionary" that will allow the user to use the coding method with which he is most familiar or to change to a new coding scheme designed by the user.

4. The "international index code" entry method.

Chinese character international index codes are four-digit hexadecimal codes, used, for example, by sending a "30AE" to represent the character for "to love." The transmission steps are as follow: press the "international index code" function key and the computer will then be placed in the international code status. Then, enter a "30AE" and press the space bar. The computer will display the character for "to love." If more than 4 digits are entered, then the code will automatically be discarded, only the last four codes being accepted. With international coding, Japanese and Russian may also be entered.

The four entry methods just described are controlled by corresponding function keys, and methods may be changed at any time for greater convenience.

Independent Chinese Character Associative Functions

There is an associative dictionary in the LX-80A system that contains tens of thousands of common words and phrases. As each Chinese character is entered, the computer guesses the next possible word based on the dictionary, and then displays this word on the screen prompt area. The operator may then directly choose this word. A character will bring up a group of characters (26), which is very like the human associative function. In this way, and by interlocking associations, a large number of words, phrases, and even whole sentences can be generated. The partial associative structure for the character 'zhong' in Figure 3 is shown with arrows indicating the directions.

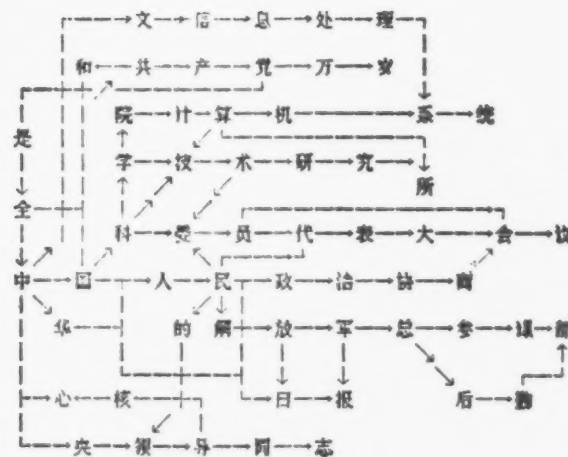


Figure 3

Use of the associative function is very easy and may be divided into the associations with "characters" and the associations with "words."

1. Associations with "characters."

This associative function is controlled by function key F7. Pressing this key will present the word "association" in the prompt area, indicating that the computer has entered the associative state. If the character "zhong" is entered, 26 characters like "hua" and "guo" will appear in the prompt area. After choosing "guo," 26 words like "qi," "jia," and "ke" will appear in the prompt area. In this way, entry of the five characters "Zhongguo Kexue Yuan" ["Chinese Academy of Sciences"] can be by the associative method and need not be entered by the character at a time method described earlier.

2. Associations with "words."

This is controlled by function key F9, and if after entering the character 'zhong' F9 is pressed again, many words and phrases associated with the character 'zhong' will appear in the prompt area, as for example, "leading comrades of the Central Committee," "Chinese Academy of Sciences," etc., and when there are many associated words and phrases, they may be displayed by repeated pressing of F9. If a particular phrase is to be entered, the key corresponding to the final character in the associated phrase may be pressed and the entire word or phrase will be entered into the computer. The longer the sentences are, the higher the efficiency.

There is associative function support for each of the character input methods described above, which allows character input speed to reach an average of 1.5 key presses per character.

The First Chinese Character Command System

Command operation of the LX-80A system itself is now by Chinese characters. Twenty-six Chinese character commands have been burned onto a 64 kb EPROM, and upon system reset, the 26 character commands are all displayed in the prompt area by their functions. As shown in Figure 4, if the user wishes to see the file directory of the current disk, he may press 'Q,' and the screen will then immediately display the file directory and will also tell the user the size of each file. If one wishes to know which operations commands are represented by the English letter keys, press 'W' and the screen will display the meaning of each command.

The LX-80A is a multi-function, stand-alone Chinese language computer system having 576 kb of RAM and two floppy disk drives, with a 24 pin printer. It can be used for document processing, storage and display, and for printing. It is equipped with a standard interface (RS-232) and may be connected with a variety of host computers, which makes the LX-80A a powerful Chinese language terminal.



Figure 4

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INVESTIGATION OF UNDULATOR FOR HEFEI 800 MEV ELECTRON STORAGE RING

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 3, May 86 pp 316-322

[Article by Chen Zihcheng [7115 1807 6134] and Liu Jian-yang [0491 1696 2254], China University of Science and Technology, and Xu Jianming [1776 1696 6900], Institute of High Energy Physics, Chinese Academy of Sciences: "The Investigation of an Undulator for the Hefei 800 MeV Electron Storage Ring"; paper received on 11 March 1985]

[Text] Abstract: A permanent magnet undulator for the Hefei 800 MeV electron storage ring is now under construction. This paper introduces undulator radiation characteristics and magnet design considerations and reports on the design, development, and magnetic field measurement results of a 10 period hybrid undulator model.

I. Introduction

An undulator is a periodic magnetic device which, when inserted into the electron ring's linear section, can supply quasi-monochromatic synchronous radiation light of greater brightness than the radiation produced by a wanzhuan [1737 6567 turning?] magnet, and thus becomes an important insertion component of storage rings. Its technical reliability has been verified by successful experiments by many laboratories abroad.¹ The undulator has the following three primary features: 1) The special structure of the undulator magnet makes the ring's electron beam not produce net deflection or shifting and does not have a serious influence on the electron beam movement; 2) In the wanzhuan magnet, the electron beam radiates a continuous and smooth light spectrum, but in the undulator, the interference effect of the radiation suppresses the radiation light in some wavelengths, thus in specific wavelengths it is intensified, and the radiation is concentrated within a narrow wavelength interval, and the light spectrum obtained is several narrow quasi-monochromatic light peaks; 3) The radiation focuses within a very small space solid angle along the axis, and has a high spatial brightness and collimation, which reduces the heat given off by the beam ray components, and radiation power can be more effectively utilized.

When high magnetic energy rare earth metal permanent magnet material is used for the undulator magnet, an excitation current is not required, there is no

power loss, manufacturing expenses can be saved, and the magnetic period length is greatly reduced, to obtain short radiation wave lengths and full utilization of the limited storage ring linear section space. Permanent magnet undulators do not require other added equipment which greatly simplifies the complexity of building the magnet.²

This paper introduces the magnet design of the Hefei 800MeV electron storage ring's undulator and the mechanical structure of the undulator model and the magnetic field measurement results.

II. Design of the Undulator Magnet

A hybrid magnetic path design was adopted for the Hefei storage ring's undulator magnet.³ The hybrid is an alternating arrangement of samarium cobalt (SmCo_5) permanent magnet and soft iron, which mix to form the magnetic path (Figure 1). The permanent magnet plays the role of the "source" which excites the magnetic flux, and the magnet's magnetized direction along the axis changes alternately by 180° , the soft iron is used as a magnetic pole, on the central plane of the magnetic a sinusoidal period magnetic field will be produced, i.e., $B_z = B_0 \sin 2\pi \frac{s}{\lambda_u}$, in which B_0 is the peak magnetic field, λ_u is the undulator mag-

netic period length, s is the length along the axis. The hybrid magnet has the following two beneficial features: 1) The hybrid magnet's field distribution is mainly derived from the surface shape of the magnetic pole, the homogeneity of magnetic material performance need not be strictly demanded; 2) each peak magnetic field which corresponds to the magnetic pole can be fine tuned using a magnet tuning screw, thus higher uniformity of peak field can be obtained.

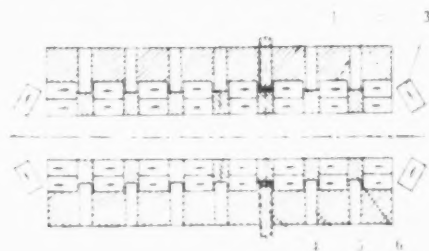


Figure 1. Diagram of Hybrid Undulator

Key:

- | | |
|---------------------------|----------------------------|
| 1. Support | 4. Magnet tuning screw |
| 2. Permanent magnet | 5. Screw-hole |
| 3. Rotating magnetic pole | 6. Soft iron magnetic pole |

We used a limited differential calculation program to design the magnetic path, and at the same time carried out an analysis of the hybrid magnet's field distribution.⁴ The fundamental wave of the peak magnetic field can be expressed as

$$B_z = \frac{4B_r}{\pi} \left\{ \left(\frac{4\pi M_r}{B_r} \right) \left[1 - \frac{\lambda_u}{2\pi h_1} (1 - e^{-\frac{2\pi h_1}{\lambda_u}}) \right] \sin \frac{\pi l_1}{\lambda_u} + (1 - e^{-\frac{2\pi h_2}{\lambda_u}}) \sin \frac{\pi l_2}{\lambda_u} \right\} e^{-\pi z/\lambda_u} \quad (1)$$

in which B_r is the intensity of the permanent magnet's residual magnetism, h_1 , h_2 , and l_1 , and l_2 are the height and length of the soft iron magnetic pole and the permanent magnet, respectively, in which

$$h_1 = \frac{2}{3} h_2,$$

$$\left(\frac{4\pi M_z}{B_r} \right) = \frac{\pi h_1 l_2}{K_3 \pi l_1 l_2 / 2 + K_r \lambda_u h_1 l_2 (\pi g / \lambda_u)}$$

K_3 and K_r are the leakage coefficient and the magnetic resistance coefficient.

Depending on the undulator radiation characteristics, when $K^*=1.2$, the first harmonic of the radiation light has the highest brightness, and the second, and fifth harmonic also can obtain higher brightness. The undulator radiation brightness and the spectral line width are determined, to a considerable degree, by the magnetic period number, i.e., $\frac{d^2 I}{d\omega/\omega dQ} \propto N^2$, $\frac{\Delta\lambda}{\lambda} \propto \frac{1}{N}$. The Hefei storage

ring undulator was designed on this basis. When $\lambda_u = 4.8\text{cm}$, $l_1 = \lambda_u/6$, $l_2 = \lambda_u/3$, and $h_2 = 2.7\text{cm}$, the undulator path is more ideal and can fully utilize the magnetic performance of the magnet. When $g/\lambda_u = 0.5$, the peak magnetic field can reach $B_0 = 0.29\text{T}$, correspondingly, $K = 1.3$, the magnetic field's third harmonic component is smaller than 3.5 percent, and thus is a sinusoidal distribution which is a very good approximation. The linear section free space left in the design of the Hefei storage ring for the undulator permits the undulator length to be 2.1m. At least 40 magnet periods can be arranged in such a length, and their radiation characteristics are given in Table 1.

The minimum useful gap of the undulator magnet is limited by the beam vacuum pipe's vertical aperture. After the undulator has been inserted into the storage ring there should be a guarantee that the storage beam's life will not be influenced to obtain a beam of sufficient length and to reduce beam loss, the undulator gap should at least satisfy

$$g > 14\sigma_y \quad (2)$$

σ_y is the mean-square-root half-height of the beam at the magnet outlet, taking into account the possible closed-track distortion of the beam, it is necessary to add a certain safety coefficient. Assuming an average vertical distortion $\langle \delta y_c \rangle \approx 6\text{mm}$, we designed vacuum tube wall thickness and installation gap, taking the minimum gap $g = 2.4\text{cm}$.

In the vertical direction, the undulator is symmetrical relative to the central plane of the path, relative to the central point, the magnet is roughly symmetrical, and at the central point there is a maximum magnetic field value. After the electron beam goes through the undulator, it cannot have net path shift or deflection, thus it demands that there may be any net dipolar magnetic field. To compensate for the influence of a new dipolar field, it is necessary to install adjustable magnetic poles at both ends of the magnet and by adjusting

*K is the undulator's magnetic deflection parameter, i.e., $K = 0.934 B_0 (\text{T}) \lambda_u (\text{cm})$.

marginal magnetic fields make the integral along the axis zero, i.e., $\int B ds = 0$. But in fact, it is not easy to tune $\int B ds = 0$, thus we provided a restriction $\int B ds \leq 150 \text{Gs-cm}$ to make the closed track distortion caused by the net dipolar field unimportant.

When the electron beam goes through the undulator, the vertical direction movement transform matrix is

$$M_y = \begin{bmatrix} \cos K_{eq} s & \frac{1}{K_{eq}} \sin K_{eq} s \\ -K_{eq} \sin K_{eq} s & \cos K_{eq} s \end{bmatrix} \quad (3)$$

in which $K_{eq} = \frac{1}{\sqrt{2}} \frac{K}{\gamma} P_0$, $P_0 = \frac{2\pi}{\lambda_u}$. Thus we bring about a change in the storage ring symmetry and work point. Through matrix operations, we can provide the vertical direction movement's phase shift, and oscillation number and the change of the partial β_y function as

$$\begin{cases} \Delta\mu_y = -\frac{\beta_y K_{eq}^2 L}{2} \left(1 - \frac{L^2}{4\beta_y^2}\right) \\ \Delta\nu_y = \Delta\mu_y / 2\pi \\ \Delta\beta_y / \beta_{y0} = \left(1 + \frac{L^2}{4\beta_y^2}\right) \sin \mu_y / (\sin \mu_y + \Delta\mu_y \cos \mu_y) - 1 \end{cases} \quad (4)$$

The working point of the storage ring's vertical direction movement is $\nu_y = 2.58$, on the basis of the storage ring and undulator parameters given previously, we can obtain $\Delta\mu_y = 0.0152$, $\Delta\nu_y = 0.0024$, $\Delta\beta_y / \beta_y = 0.05$. Change in the working point is within the permitted range, and by regulating other focusing parameters, the symmetry of the storage ring can be basically restored to its original state.

The quadruple effect of the horizontal component B_x will cause a correction in the storage ring beam optics, but for weak field undulators and higher energy electron beams, the influence of the magnetic field's quadruple effect is very small. If the maximum relative error of the magnetic field is $\frac{\Delta B}{B_0} = 5\%$, then

when $K=1.2$, the path shift of the beam's lateral movement horizontally and the increase in beam angular scattering are respectively $\Delta x = 2.7 \times 10^{-3} \text{mm}$, and $\Delta x' = 2.8 \times 10^{-3} \text{mrad}$, and the disturbance of the beam is very small.

The basic parameters of the Hefei 800 MeV electron storage ring undulator insertion section center are as follows (when the ring's coupling coefficient is 0.1):

Beam emmissivity	$\epsilon_x = 0.1215 \text{mm-mrad}$	$\epsilon_y = 0.0122 \text{mm-mrad}$
amplitude function	$\beta_x = 21.5481 \text{m}$	$\beta_y = 3.4147 \text{m}$
beam lateral dimensions	$\sigma_x = 1.6184 \text{mm}$	$\sigma_y = 0.2037 \text{mm}$
beam scatter angle	$\sigma'_x = 0.0751 \text{mrad}$	$\sigma'_y = 0.0597 \text{mrad}$

Thus, a 40 period undulator placed in the insertion section's radiation brightness will be 10^3 higher than the wanzhuan magnet. Figure shows the radiation spectrum in the undulator and the wanzhuan magnet.

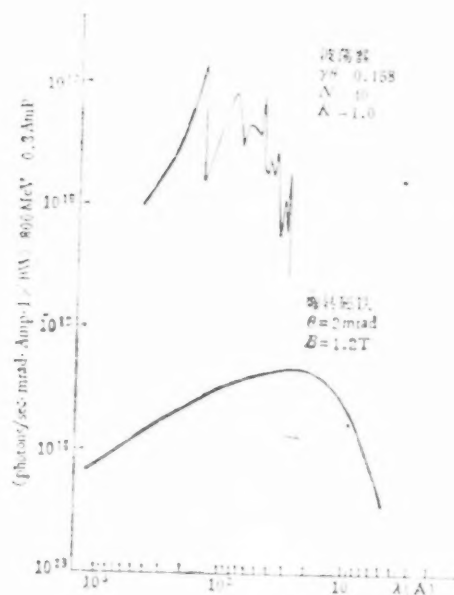


Figure 2. Radiation Spectrum of Undulator and Wanzhuan Magnet

Tuning the intensity of the undulator's magnetic field can tune the radiation wave length. When the magnetic parameter K is tuned between 0.4 and 0.2, by using first, third, and fifth harmonics, the range of the useable operating wavelength is 20-168Å. Table 1 gives the calculated results of several groups of characteristic parameters of the Hefei synchronous radiation device using a 50 period undulator ($\gamma=1565.56$, $l=0.3A$, $\lambda_u=4.8cm$, $N=40$).

Table 1.

magnet parameter	harmonic number	harmonic wave-length	natural line width	radiation brightness	total radiation
K	k	$\lambda(\text{\AA})$	$\frac{\Delta\lambda}{\lambda}(\%)$	(Phs/sec, mrad ² , A, 1%BW)	(Watts)
0.4	1	106	2.5	5.1×10^{14}	2
	3	35	0.83	8.6×10^{14}	
	5	21	0.5	1.0×10^{14}	
0.8	1	129	2.5	1.3×10^{17}	8
	3	43	0.83	2.4×10^{16}	
	5	25	0.5	2.9×10^{15}	
1.2	1	168	2.5	1.6×10^{17}	18
	3	56	0.83	8.4×10^{16}	
	5	34	0.5	3.0×10^{16}	

III. Undulator Model and Magnetic Field Measurements

The undulator magnet model was developed to build a 2.1m, 40 period undulator with the aim of gaining some experience in the magnet design, mechanical structure and processing technology, to provide measurement parameters of magnet performance. The model used the magnetic path parameters given above, but the overall length was reduced which diminished the use of a permanent magnet. Table 2 gives the basic parameters of this model.

Table 2.

Material	SmCo ₅ soft iron
Permanent magnet residual magnetic intensity B_r	0.9T
Magnet period length λ_u	4.8cm
Permanent magnet specifications	1.6cm (magnetized direction)x7.5cmx1.8cm
Soft iron magnetic pole specifications	0.8cmx7.5cmx1.2cm
Magnetic period number N	10
Magnetic pole number	10 pairs
Overall model length L	0.6m
Adjustable gap range g	2.4-6.0cm
Peak magnetic field B_0	0.22T(g=2.4cm)

For ease of loading and use, the undulator model was designed in a "C" shape, the structure primarily made up of upper and lower cope plates and framework, the permanent magnet and soft iron magnetic poles are cemented to an aluminum "U" shaped holding plate which is screwed to the cope plate, so the upper and lower magnetic poles are facing each other. Three independent manual adjustment systems are used to adjust the gap and the rotating magnetic poles at the ends. When adjusting the gap, the upper and lower cope plates moved relative to the central plane, when the gap is large, the magnetic field is weak, when the gap is small, the magnetic field is strong. The rotating magnetic poles can be adjusted to any angle to facilitate adjusting the peripheral magnetic fields to make the magnetic field's axial integral $\int B ds = 0$. At the outer edge there is a magnetic screen intended to eliminate the magnet's influence on other components, and to make the peripheral magnetic field rapidly drop to zero. At the other end there is also a guide rod to reduce wobbling when the cope plate is being adjusted.

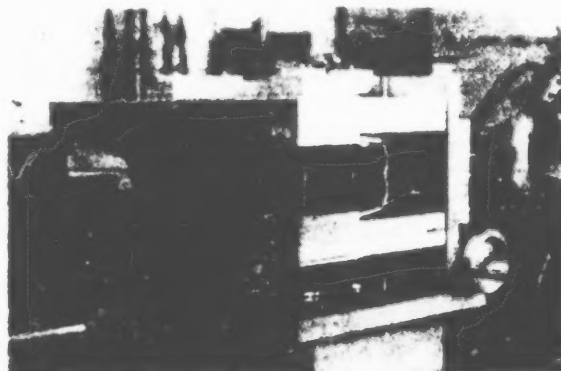


Figure 3. Photograph of Undulator Model

Each period of the model's magnet requires 16 permanent magnets, including the rotating magnetic poles at the ends, so a total of 168 permanent magnets were used. The permanent magnet performance parameters are $B_r = 9065 \pm 288 \text{Gs}$, $H_c = 7544 \pm 170 \text{e}$, the magnet's energy accumulation [nengji 5174 4480] $< BH \bar{m} \approx 18 \text{MOeGs}$.

The magnet was measured by a huorpian [7202 1422 3651] (Ge) fixed to an x-y-z three dimensional support, the huorpian's sensitive area was $1.5 \times 4 \text{mm}^2$, the temperature coefficient was $5 \times 10^{-4} / ^\circ\text{C}$, at the time of the measurement, the room temperature was held to $26 \pm 0.5 ^\circ\text{C}$. The overall measurement precision was 3×10^{-3} . Measurement step length was 2mm. The magnetic field measurements are summarized below (for measurements see Table 3):

1) On the central plane of the undulator, the distribution of the vertical field component axially is sinusoidal. Figure 4 gives the magnetic field distribution when $g=2.4\text{cm}$ and a period field distribution for different gaps, the third harmonic wave component of the magnetic field is smaller than 0.5 percent, much smaller than the anticipated harmonic wave. Because of differences in performance of the magnets and processing and installation, at the time of the initial measurements, there was a definite fluctuation of the peak magnetic field, but after using the magnet adjusting screw, the average of the peak field improved greatly with an average better than $\frac{1}{\text{MKZ}}$.

2) The magnets at the end can be adjusted to any angle, to make $\int B ds = 0$. The angle adjustment changes with the size of the gap. When $g=2.4\text{cm}$, the adjustable range of end rotating magnetic poles within the 90° angle range is 1900Gs-cm . The axial integral of the vertical field component and horizontal field component were measured at different gaps, and the results of the measurements were less than 150Gs-cm , satisfying design demands.

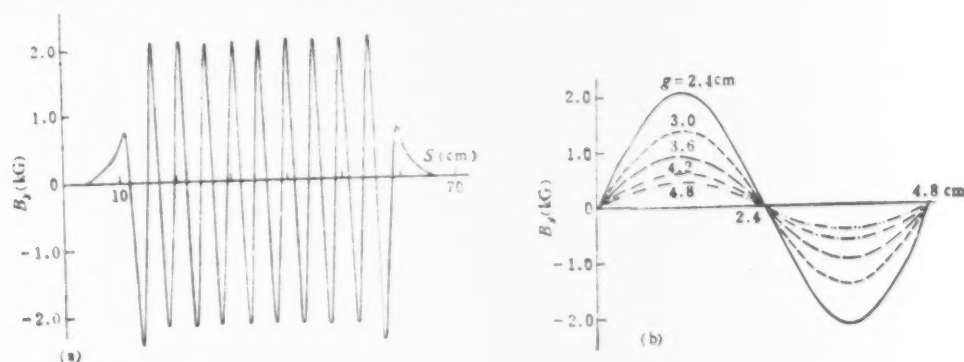


Figure 4. Magnetic Field Distribution Curves

Key:

- (a) Magnetic field axial distribution when $g=2.4\text{cm}$
- (b) Magnetic field distribution of one period at different gaps

3) For the vertical field component of sinusoidal distribution along the axis, where the value was at the maximum, the average area was small, thus the average area measured at the point of peak field can characterize the average

of the entire magnet. We measured the lateral field area of the deviating $\pm 1\text{cm}$ from the beam axis on the central plane at different gaps, and gave the relative deviation relative to the axial peak magnetic field. It can be seen from the measurement results that the deviation is far smaller than the $\pm 5\%$ demanded by beam optics.

Gap (cm)	Average Peak magnetic (Gs)	Peak field average (Gs)	Vertical field integral (Gs-cm)	Horizontal field integral (Gs-cm)	Relative magnetic field deviation of $\pm 1\text{cm}$ good field area
2.4	2173	39	4.8	-93.4	0.2
3.0	1466	42	-19.9	-71.4	0.29
3.6	994	41	-78.1	-67.5	0.38
4.2	672	41	-67.8	-51.0	0.43
4.8	465	40	51.0	-70.1	0.58

The mechanical structure of this model is very simple and the adjusting system flexibility is stable. The measured fields of the model's magnetic path design achieved anticipated demands.

In the area of mixed undulator field shape analysis we had beneficial discussions with Comrades Liu Maosan [0491 5399 0005] and Chen Renhuai [7115 0088 2037] of the High Energy Institute.

In the area of magnetic field measurement we were greatly aided by Comrade Yan Heping [7051 0735 1627], and here we express our gratitude to all of them.

References

1. G. Brown, K. Halbach, J. Harrio, and H. Winick, N.I.M. 208 (1983) 65.
2. M.W. Pool and R.P. Walker, PERIODIC MAGNETS FOR UNDULATORS AND FREE ELECTRON LASER, the International Conference on Magnet Technology, 1981.
3. E. Hoyer et al., IEEE TRANS., NS-30(1983) 3118.
4. Liu Maosan [0491 5399 0005], et al., PROCEEDINGS OF THE SECOND CHINA-JAPAN JOINT SYMPOSIUM ON ACCELERATORS FOR NUCLEAR SCIENCE AND THEIR APPLICATIONS, 265, Institute of Modern Physics, 1983.

8226/12232
CSO: 4008/69

SQUARE-LOOP ANTENNA FOR SHIPBOARD USE DESCRIBED

Beijing DIANZI KEXUE JISHU [ELECTRONICS SCIENCE AND TECHNOLOGY] in Chinese
Vol 16 No 5, 10 May 86 pp 16-17

[Article by Wang Guoqiang [3769 0948 1730] and Huang Ruican [7806 3843 3503]:
"A Half-Wave Square-Loop Antenna for Ship Use"]

[Text] I. Overview

Ships navigating on the ocean are typical moving bodies. Therefore, in the VHF and UHF bands, shipboard television reception antennas have to be omnidirectional and have high gain along the horizontal. At present, shipboard omnidirectional antennas in regular use are orthogonal half-wave antennas and loop antennas. This paper proposes a half-wave square-loop antenna, which in comparison with orthogonal half-wave antennas has higher gain when the number of elements is the same. What we mean by a half-wave square-loop antenna is where each side of a square-loop antenna is equal to a half-wavelength. The principle is as shown in Figure 1.

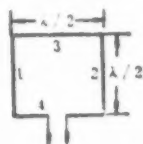


Figure 1. Square-loop Antenna Schematic

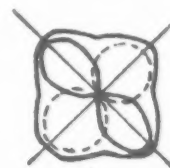


Figure 2. Directivity Chart

On the surface of the antenna, when the signal wave comes around from the vertical at side 1 (or 2), sides 1 and 2 then form a half-wave oscillating two-element antenna array. If the signal wave is turned around from the vertical in the direction of side 3 (or 4), then sides 3 and 4 form a half-wave oscillating two-element antenna array. Therefore, the gain from a half-wavelength square-loop antenna will be greater than an ordinary orthogonal half-wave oscillating omnidirectional antenna. Its omnidirectionality is fundamentally the same.

II. Directional Coefficient and Directivity Charts

As shown by the square-loop antenna in Figure 1 and by the preceding explanation, it is not hard to see that when this antenna is placed at the horizontal it is equivalent to two groups of orthogonal two-element arrays in the horizontal plane. The array elements are half-wave oscillators, and the distance between the two-element arrays is $d = \lambda/2$. Therefore, the directivity coefficient of this kind of antenna may be conveniently written as: [Zhang Fangying [1728 2455 5391]: "Antennas and Feeder Equipment," (Beijing: Beijing Kexue Joaiyu, 1962), p 431.]

$$F(\theta) = \left[\frac{\cos\left(\frac{\pi}{2} \cos\theta\right)}{\sin\theta} \cdot \sin\left(\frac{\pi}{2} \sin\theta\right) + \frac{\cos\left(\frac{\pi}{2} \sin\theta\right)}{\cos\theta} \cdot \sin\left(\frac{\pi}{2} \cos\theta\right) \right]$$

The directivity chart produced by $F(\theta)$ is shown in Figure 2. The dotted lines represent the directivity chart for sides 1, 2 of the square-loop antenna; the thin solid line is the directivity chart for sides 3, 4 of the square-loop antenna; the thick solid line is the composite directivity chart.

1. Testing the directivity chart.

When the square-loop antenna is placed at the horizontal, side 3 in Figure 1 is aligned as a radiating antenna, and this is taken as zero, then the test data is as listed in Table 1. See Figure 3 for a horizontal directivity chart as described in Table 1.

When the square-loop antenna is placed vertically, and the direction of the transmission of the signal wave on the vertical plane is zero, at this time the received signal is strongest, the test data being as in Table 2. See Figure 4 for a vertical directivity chart as described by Table 2.

Table 1

Deflection angle (degrees)	0	15	30	45	60	75	90	105	120	135	150	165	180
Maximum reading (grid)	60	57	48	36	18	7	0	57	48	33	27	18	51
Normalized value	1	0.95	0.80	0.60	0.30	0.12	0	0.95	0.80	0.55	0.45	0.30	0.85

Table 2

Deflection angle (degrees)	0	15	30	45	60	75	90	105	120	135	150	165	180
Maximum reading (grid)	0	15	30	48	69	70.5	72	70.5	69	48	30	15	0
Normalized value	0	0.20	0.41	0.66	0.95	0.97	1	0.97	0.95	0.66	0.41	0.20	0

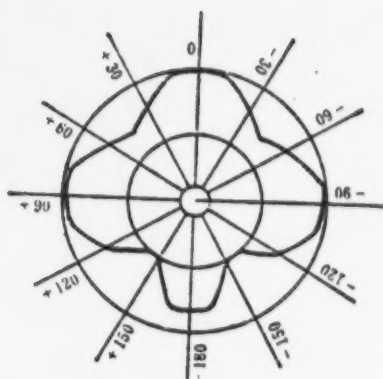


Figure 3. Horizontal Directivity Chart



Figure 4. Vertical Directivity Chart

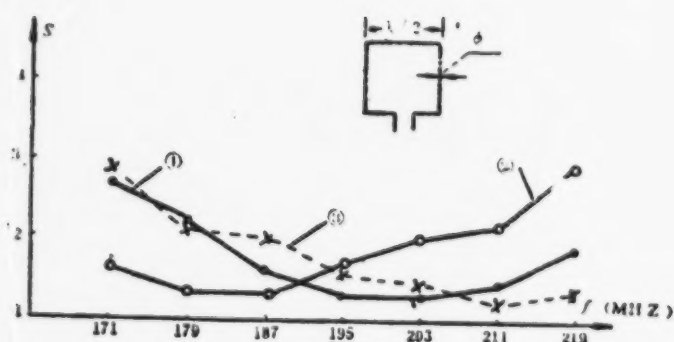


Figure 5. Relation Curves for Standing Wave Ratios and Frequencies



Figure 6. Diagram for Expanding Bandwidth

2. Testing frequency characteristics.

For these tests we selected channels 6 through 12 in the VHF band. The frequency characteristics of the half-wave square-loop antenna were indicated through tests of the standing wave ratio. The antenna input impedance was 300 ohms, and the antenna input terminal was connected through a broad band impedance transformer and 75 ohm coaxial cable.

Using a square-loop antenna made of copper wire of differing diameters, the relational curve of the standing wave ration S and the frequency f is as shown in Figure 5.

Curve 1 shows the design frequency $f_o = 195$ MHz of the square-loop antenna, where side $a = \lambda/2 = 770$ mm and the diameter of the antenna is $\phi = 4.4$ mm.

Curve 2 shows the design frequency $f_o = 195$ MHz of the square-loop antenna, where side $a = \lambda/2 = 770$ mm and the diameter of the antenna is $\phi = 1.5$ mm.

Curve 3 shows the design frequency $f_o = 203$ MHz of the square-loop antenna, where side $a = \lambda/2 = 740$ mm and the diameter of the antenna is $\phi = 8$ mm.

III. Discussion

1. There is a definite difference between the tested horizontal directivity charts and the horizontal directivity charts by theoretical analysis. The direction with the greatest dip just happens to be the direction where the signal is aligned with the side that meets the feeder line. This shows that for the side that connects with the feeder line, reception efficiency is not as good as for the sides without the feeder line. In two tiered applications of square-loop antennas, this condition should be in mind.

2. It can be seen from Figure 5 that the higher the frequency of the square-loop antenna application, the thicker should be the diameter of the material used. The curve 2 in Figure 5 shows that when the diameter $\phi = 1.5$ mm, the low point (179-187 MHz) standing wave ratio of the test frequency is smallest. Curve 1 then shows that when the diameter $\phi = 4$ mm, square-loop antennas of equal dimensions will have the least standing wave ratio at the high end (195-211 MHz). Curve 3 shows that when the antenna diameter used is $\phi = 8$ mm, the practical frequency is even higher.

3. To further develop the working frequencies of the square-loop antenna, the method shown in Figure 6 may be used for adding shorter reception antennas.

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Electronics

THEORETICAL, EXPERIMENTAL STUDY OF CAVITIES IN TWT

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1,
Jan 86 pp 7-15

[English abstract of article by Zhang Zhaohong [1728 2507 3163] and
Wu Hongshi [0702 7703 6684] of the Beijing Vacuum Electron Devices Research
Institute]

[Text] An analysis of coupled cavities in TWT is presented. The analysis employs field equivalence principle in conjunction with Green's function techniques. The resulting operator equations are solved by the moment method. The characteristics of the coupled cavities are expressed in terms of generalized admittance matrices which are functions both of frequency and dimensions of the system. The results of calculation performed with the aid of an electronic computer agree quite well with those of cold test measurements. (Paper received November 1984, finalized July 1985.)

References:

- [1] H. J. Curnow: IEEE Trans., Vol. MTT-13, No. 9, pp. 671-675, Sept. 1965.
- [2] R. I. Couier: BSTJ, Vol. 42, No. 7, pp. 1829-1861, 1963.
- [3] M. A. Allen and G. S. Kino: IRE Trans, Vol. MTT-8, No. 5, pp 362-372, 1960.
- [4] A. W. Scott and R. D. Wanselow: AD 275016, 1982.
- [5] R. G. Catel: Proc. IEE, Vol. 130, pt. I, No. 2, pp. 67-72, 1983.
- [6] J. Rodney and M. Vaughan: IEEE Trans., Vol. ED-22, No. 10, pp. 880-890, 1975.
- [7] R. F. Harrington: Time Harmonic Electromagnetic Fields, McGraw-Hill, Ch. 3, New York, 1960.
- [8] R. F. Harrington: Field Computation by Moment Method, Macmilan, New York, 1968.
- [9] R. F. Harrington and J. R. Mautz: IEEE Trans., Vol. Ap-24, No. 9, pp. 870-873, 1976.
- [10] E. G. Levchenko et al.: Radio Engineering and Electron Physics, Vol. 14, No. 8, pp. 1260-1268, 1968.
- [11] H. G. Kosmal and G. M. Branch: IEEE Trans., Vol. ED-20, No. 7, pp. 621-629, 1973.
- [12] Chen-To Tai: Dyadic Green's Function in Electromagnetic Theory, PA: Scranton, Intext Educational Publishers, 1972.
- [13] D. C. Stinson: Intermediate Mathematics of Electromagnetics, Prentice-Hall, Chapt. 5, 1976.
- [14] M. Kisliuk: IEEE Trans., Vol. MTT-28, No. 8, pp 894-898, 1982.
- [15] 张兆镛, 微波管高频系统的测量, 国防工业出版社, 1982.

DYLMOS INTEGRATED CIRCUITS: HYBRID INTEGRATED CIRCUIT WITHOUT ISOLATION

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1,
Jan 86 pp 16-20

[English abstract of article by Wang Shoujue [3769 1349 6030], Xia Yongwei [1115 3057 0251], Kong Lingkun [1313 0109 0961], Li Yuanjing [2621 6678 6975], and Ho Naimin [0149 0035 2494] of the Semiconductor Institute, Chinese Academy of Sciences, Beijing]

[Text] A new hybrid integrated circuit without isolation, DYLMOSIC, has been developed. By increasing and adjusting the technology, P channel MOS transistors and bipolar transistors with large β and small β value for the linear AND-OR gate in DYL are developed on the same wafer, based on the self-isolation characteristics among the linear AND-OR gates, the main logic unit in DYL, and MOSIC. Using the hybrid integrated technology, an inverter unit is constructed by bipolar and MOS transistors on the same N type silicon wafer. The benefits of DYLMOS hybrid integrated circuits are: simple and compatible technology with the linear AND-OR gate in DYL, high input and low output impedance and compatible level with DYL and TTL circuits. (Paper received March 1985, finalized July 1985.)

References

- [1] 王守觉、孙祥义、王润梅, 电子学报, No.2, pp. 43-51, 1978.
- [2] 王守觉、魏书铭、郑洁, 电子学报, No.1, pp.1-9, 1980.
- [3] 王守觉、李致洁等, 电子学报, No.5, pp. 9-16, 1983.
- [4] 郑启伦、黄寅光, 电子学报, No.6, pp.23-32, 1981.
- [5] 王守觉、尹元茂、景士平, 多元逻辑电路DYL时分式小型三用电话系统, 半导体所研究报告.
- [6] 郑启伦等, MDA-016型电话系统研制报告, 华南工学院研究报告, 1984.
- [7] 王守觉、王宏道、李秀贤, 多元逻辑电路万能函数发生器, 半导体所研究报告.
- [8] Lee Shi-chua, VLSI Design, Vol.5, pp. 98-100, 1980.

INFLUENCE OF MISALIGNMENT OF ELECTRON LENSES ON IMAGE-QUALITY

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1,
Jan 86 pp 21-29

[English abstract of article by Tong Linsu [4547 2651 1121] and Wu Changjin
[0702 1603 3160] of the Nanjing Institute of Technology, Jiangsu]

[Text] The misalignment of the rotationally symmetrical electron optical system caused by manufacturing and assembling tolerance is an important limitation factor for further improving the image quality. The finite-difference method is first used to calculate the three-dimension field to analyze the problem of the misaligned electron lense. The influence of the misalignment of equidiameter cylinder bipotential immersion electron lense on image quality is given. Experimental tubes are also manufactured. It is shown that the theoretical computations are in good agreement with experimental values. (Paper received September 1984, finalized March 1985.)

References:

- [1] O. Klemperer et al.: Electron Optics, Cambridge Press, 3rd ed., 1971.
- [2] A. B. EL-Kareh et al.: Electron Beams, Lenses and Optics, Vol. I & II. Academic Press, 1970.
- [3] V. K. Zworykin et al.: Electron Optics and the Electron Microscope, John Wiley, N. Y., 1945.
- [4] 沈庆瑛: 摄像管的理论基础, 科学出版社, 1984.
- [5] 西门纪业: 电子和离子光学原理及象差导论, 科学出版社, 1983.
- [6] H. Moss et al.: Proc. Inst. Elec. Engrs (London) Part. II, Vol. 97, p.277, 1950.
- [7] D. M. Sutherland: IREE Australia, Vol. 27, p. 299, Nov. 1986.
- [8] 西门纪业, 陈千寿: 电子学报, 第4期, p. 72, 1984.
- [9] 西门纪业, 吴中和: 电子学报, 第3期, p.24, 1984.
- [10] W. D. Riecke: Optik, Vol. 24, No.5, p.397, 1986/87.
- [11] W. D. Riecke: Optik, Vol. 36, No.1, p.86, 1972.
- [12] D. L. Say et al.: IEEE Trans., Vol. CE-21, No.1, p.57, 1975.
- [13] D. M. MacGregor: IEEE Trans., Vol. CE-20, No.3, p.318, 1983.
- [14] B. A. Carre' et al.: Radio and Electronic Engineering, Vol.27, No.6, p.446, 1984.
- [15] I. P. Csorba: RCA Rev., Vol. 31, p.534, 1970.
- [16] I. P. Csorba: RCA Rev., Vol.33, p.393, 1972.

NEW METHOD OF MEASURING TWO-PORT DEVICES BY SIX-PORT REFLECTOMETER

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1,
Jan 86 pp 44-50

[English abstract of article by Sun Jia [1327 4471] of the Chengdu Institute
of Radio Engineering]

[Text] A new circuit is given for measuring scattering parameters of any two-port microwave network by means of a single six-port reflectometer. Based on the wave superposition theory and the theory of equivalent circuit, a new method of calibration and measurement is described. (Paper received July 1984, finalized July 1985.)

References:

- [1] G.F. Engen: The six-port reflectometer: an alternative network analyzer, IEEE Trans., Vol. MTT-25, pp. 1075~1079, 1977.
- [2] C.A. Hoer: Calibrating a six-port reflectometer with four impedance standards, NBS. Tech. Note 1004, 1978.
- [3] S.H. Li, R.G. Bosizio: Calibration of multiport reflectometers by means of four open/short circuits, IEEE Trans., Vol MTT-30, pp. 1085-1090, 1982.
- [4] G.F. Engen, C.A. Hoer: Thru-Reflect-Line': An improved technique for calibrating the dual sixport automatic network analyzer, IEEE Trans., Vol. MTT-27, pp. 987-992, 1979.
- [5] 孙稼: 双六端口网络分析仪的校准与测量的新分析, 成都电讯工程学院学报, 第3期, 1984年.
- [6] 孙稼: 双六端口网络分析仪校准与测量的一种新方法, 电子学报, Vol. 12, No. 6, 1984年.
- [7] 李世鹤, R.G. Bosizio: 六端口反射仪的分析及最佳电路设计, 电子学报, Vol. 11, No. 2, 1983年.
- [8] A.L. Cullen: Measurement of 2-port devices by a reflectometer system, IEE. Proc., Vol. 129. Pt. H, pp. 333~337, 1982.
- [9] Sun Jia: New application of a single six-port reflectometer, Elec. Lett., Vol. 20, No. 22, pp920~922, 1984.

CONSTRAINED OPTIMIZATION DESIGN OF ELECTRON OPTICAL SYSTEM USING COMPLEX METHOD

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1, Jan 86 pp 51-57

[English abstract of article by Gu Changxin [7357 2490 9515] and Shan Liying [0830 5461 5391] of the Modern Physics Institute, Fudan University, Shanghai]

[Text] The constrained optimization method-complex method described in this paper is better than the simplex method for design of electron optical systems. This method is beneficial to making optimal automatic search and can ensure that the computed results will satisfy the design requirement. In the complex method as well as simplex method, it is not necessary to know the explicit functional relation between the objective function and the searching parameters. Comparing with other optimization methods, the complex method and simplex method have significant advantage in the optimization design of electron optical systems. (Paper received May 1984, finalized February 1985.)

References:

- [1] P. P. Kas'yankov et al.: Metoday Recheta Electronno-Opticheskikh System, Novosibirsk, Vol. 62, p.68, 1970.
- [2] R. W. Moses: Rev. Sci. Instrum., Vol. 42, p. 828, 1971.
- [3] R. W. Moses: Proc. Roy. Soc. (London), A330, p. 483, 1974.
- [4] H. Rose, R. W. Moses: Optik, Vol. 37, p. 316, 1973.
- [5] P. W. Hawkes: Computer Aided Design in Electron Optics, Computer Aided Design, Vol. 5, p.200, 1973.
- [6] E. Munro: J. V. S. T., Vol. 12, p. 1146, 1975.
- [7] M. Szilagyi: Optik, Vol. 48, p. 215, 1977.
- [8] M. Szilagyi: Optik, Vol. 49, p. 223, 1977.
- [9] M. Szilagyi: Optik, Vol. 50, p. 51, 1978.
- [10] 华中一、顾晶庭: 扩展场透镜的计算机分析, 上海电子学会1978年年会论文摘要。
- [11] 顾晶庭等: 电子学报, No.2, p. 41, 1984.
- [12] J. A. Richardson, J. L. Kuester: The Complex Method for Constrained Optimization, Communications of the ACM, Vol. 16, p.487, 1973.
- [13] A. B. EL-Kareh, J. C. J. EL-Kareh: Electron Beams, Lenses and Optics, Vol. 2, p.46, 1970.
- [14] 上海科学技术情报研究所: 国外电子管概况, p. 143, 1973.

ON-LINE FAULT DIAGNOSIS OF ANALOG IC

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1,
Jan 86 pp 65-72

[English abstract of article by Zhao Guonan [6392 0948 0589], Xie Shuang [6200 7208], and Guo Yushun [6753 5940 7311] of the Hangzhou Institute of Electronics Engineering, Zhejiang]

[Text] The following new ideas are presented for use in on-line fault diagnosis of analog integrated circuits.

1. The number of fault elements in an analog circuit can be evaluated from the measured data upon the limited number of accessible terminals.
2. The dependent relation between any two multiple-fault sets can be classified in two kinds: the mutual dependence and the single dependence. The routine of on-line fault diagnosis can be accelerated with the use of mutual dependence.
3. The idea of effective measuring ports is helpful to the topological judgment of diagnosability of certain multiple-fault set besides the examination of the existence of loops and cutsets among the fault elements.
4. The uniqueness of the values of certain existing fault elements calculated from the measured data upon the different measuring ports can be used to distinguish the actual fault from the guessed fault.

Program based on the algorithm derived from the above ideas has been proved with success. (Paper received October 1984, finalized April 1985.)

References:

- [1] Duhamel et al.: Special issue on automatic analog fault diagnosis, IEEE Trans., Vol. CAS-26, July 1979.
- [2] R. Saeks, S. R. Liberty: Rational Fault Analysis, Marcel Dekker, 1977.
- [3] W. Hochwald et al.: A DC approach for analog fault dictionary determination, IEEE Trans., Vol. CAS-25, pp. 523-529, 1978.
- [4] L. Rapisardo, R. A. DeCarlo: Analog multifrequency fault diagnosis, IEEE Trans., Vol. CAS-30, pp. 432-441, 1983.
- [5] H. Navid, A. N. Willson: A theory and an algorithm for analog circuit fault diagnosis, IEEE Trans., Vol. CAS-26, p440, July 1979.

- [6] T. N. Trick, G. J. Alajajian: Fault analysis of analog circuits, Proc. of 20th Midwest Symposium on CAS, Part 1, 1977.
- [7] R. M. Biernacki, J. W. Bandler: Multiple fault location of analog circuits, IEEE Trans., Vol. CAS-28, p. 301, 1981.
- [8] C. C. Wu et al.: Analog fault diagnosis with failure bounds, IEEE Trans., Vol. CAS-29, p. 277, 1982.
- [9] 赵国南: 模拟电路故障诊断及无接触测试, 杭州电子工业学院学报, No. 2, 1982.
- [10] 赵国南: 端口测试在模拟电路故障诊断中失效的判断, 杭州电子工业学院学报, No. 2, 1983.
- [11] 赵国南: 用线性故障方程的模拟电路在线诊断, 杭州电子工业学院学报, No. 1, 1984.
- [12] 赵国南, 郭裕明: 组件连接模型多故障模拟电路的故障诊断, 杭州电子工业学院学报, No. 1, 1985.

STATISTICAL COMPUTATION OF COMPRESSION RATIO FOR ZERO-ORDER PREDICTOR WITH
FLOATING-APERTURE ALGORITHM

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1,
Jan 86 pp 72-79

[English abstract of article by Guo Guirong [6753 2710 5554] and Shen Qiang
[3947 1730] of the Changsha Institute of Technology, Hunan]

[Text] The problem of statistical computation of compression ratio for zero-order predictor with floating-aperture algorithm is considered. Markov Chain is proposed as the model of input process. By this, analytical expressions are derived for the mean and mean-square value of compression ratio, and then a simple and convenient algorithm is developed for the computation of these factors. Finally, several numerical results are given to demonstrate the effectiveness of this approach. (Paper received July 1983, finalized July 1985.)

References:

- [1] AD-707333.
- [2] L. Ehrman: Analysis of some redundancy removal bandwidth compression techniques, Proc. IEEE, Vol. 55, No. 3, pp. 278-287, 1967.
- [3] А. С. Голубков, А. В. Шаронов, С. В. Касаткин: Аналитический метод оценки характеристик одного класса телеметрируемых процессов, Изв. Вузов СССР, Приборостроение, No. 5, Т. 18, 1975.

THEORETICAL ANALYSIS ON INTERMODULATION NOISE IN ANALOG MICROWAVE TRUNKS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1,
Jan 86 pp 80-86

[English abstract of article by Yang Yunnian [2799 6663 1628] of the Fourth
Research Institute of the Ministry of Posts and Telecommunications, Xian]

[Text] A theoretical formula to explain the intermodulation noise, which is produced by general transmission characteristics with higher terms in an analog microwave trunk, is obtained by use of the Bessel function expression. The usual equations for calculating the intermodulation noise in engineering practice are special cases of the presented formula. To analyze a general transmission characteristic with higher terms in microwave trunk, the least-squared principle is recommended and satisfactory results are obtained. Therefore, a good way to calculate the intermodulation noise in practical transmission systems and to analyze effects of the transmission characteristics in trunk on the FM multiplex telephony signal of radio relay systems are provided. (Paper received July 1984, finalized February 1985.)

References:

- [1] 内野俊治: 通話成果報告, No.6, 1959.
- [2] 松本高士: 電子通信学会誌, Vol. 40, No. 9, pp 950~961, 1958.
- [3] R. G. Medhurst: P.I.E.E., Vol. 107, No. 11, pp.120~126, March 1960.
- [4] С. В. Бородин: Электросвязь, No.1, стр. 1~13, 1967.
- [5] G. J. Garrison: Intermodulation distortion in FDM FM systems - A tutorial summary, IEEE Trans., Vol. COM-16, April 1968.
- [6] マイクロ波技術研究会編: マイクロ波通信工学, 昭547E (1972年).
- [7] S. Yonezawa: Microwave Communication, Maruzen Co., TOKYO, 1965.

INPUT METHODS OF CHINESE INFORMATION PROCESSING SYSTEM

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14 No 1,
Jan 86 pp 99-107

[English abstract of article by Zhao Pozhang [6392 3789 3864] of the Beijing Institute of Information and Control]

[Text] The five-layer structure model for Chinese information processing system is proposed, and the features of its input method are discussed. Also presented are the idea of general purpose Chinese character input coding module and the technical feature of natural input method—character recognition and speech recognition briefly. (Paper received May 1985, finalized September 1985.)

References:

- [1] 赵珀璋, 计算机中文信息处理(第二稿), 1~4册, 中国科学院研究生院讲义, 1984年7月。
- [2] 中华人民共和国国家标准: GB2312-80信息交换用汉字编码字符集 基本集, 技术标准出版社, 北京, 1981年。
- [3] 曷日迪, 蒙文信息互换标准代码的设计方案, 中文信息处理国际研讨会论文集, 第二集, 北京, 1983年。
- [4] 金跃中, 蒙文信息的基本情况与蒙文八位编码设计方案, 武汉工业控制计算机外设研究所资料, 1984年。
- [5] 曷日迪·木沙, 维文信息互换标准代码方案设计, 新疆维吾尔自治区阿克苏地区行署资料, 1984年。
- [6] 苏丹等, PC-8000(B)微型计算机上维吾尔文、哈萨克文符号处理系统, 新疆大学物理系信息科学研究室资料, 1984年。
- [7] 胡康发, 计算机藏文文字处理系统(ZWGL)简介, 甘肃省计算中心资料, 1984年。
- [8] 彭东城等, 壮文信息储存与检索, 广西民族学院图书馆资料, 1984年。
- [9] 金虎彪, 微型机多种文字处理系统, 中科院沈阳计算技术研究所资料, 1984年。
- [10] 汉德英电脑处理系统, 云南省印刷技术研究所资料, 1984年。
- [11] 李一雄, 关于联想式半合成汉字输入法的几点说明, 同[3], 第一集, pp.117—119。
- [12] 郭治方, 汉字编码的现状与发展, 同[3], 第三集, pp. 1—15。
- [13] 胡寅华等, 汉字字根编码的探讨, 同[12], pp.134—137。
- [14] 张晋, 汉字部件分析的方法与理论, 同[12], pp.145—153。
- [15] 唐继, 汉字编码多路输入系统, 同[12], pp.177—183。
- [16] 唐继兴等, 汉字结构识别, 同[2], pp.129—137。
- [17] 王翰龙, 汉字输入试析, 中国仪器仪表学会汉字信息处理系统研究会第一届学术年会论文集, pp.82—88, 杭州, 1981年。
- [18] 李斌, 平面联想式汉字编码设计, 全国汉字信息处理系统学术会议论文集, pp. 330—332, 承德, 1982年。

- [19] 石云程: 谈谈“笔字”输入的前途与字盘方案, 同[17], pp. 77—81.
- [20] 张善等: 略谈综合键盘设计思想, 同[17], pp. 59—67.
- [21] 金虎彪: 脱-联机式笔触汉字输入机, 同[18], pp. 323—329.
- [22] 竺乃刚等: 汉字输入与人机对话, 计算机学报, Vol. 1, No. 1, pp. 33—54, 1978.
- [23] 竺乃刚: 联想式汉字处理机, 同[18], pp. 110—116.
- [24] 赵珀璋等: 浅谈汉字拼音输入方案, 北京信息控制研究所技术报告, 1982年5月.
- [25] 李约瑟: 汉语普通话新文字电脑Ⅱ型, 南开大学中文信息处理研究室资料, 1980年.
- [26] 丁一幸: 四级拼音产生式汉字输入操作方法, 杭州自动化研究所资料, 1985年5月.
- [27] 王晓龙: 汉字输入系统与系列码, 哈尔滨工业大学计算机系资料, 1985年2月.
- [28] 戴世荣等: 字元编码法, 长沙工学院计算机研究所资料, 1984年4月.
- [29] 王永民: 五笔字型计算机汉字输入技术, 河南省中文信息开发中心资料, 1984年8月.
- [30] 张武田: 可读与不可读材料模拟输入的比较研究, 中科院心理学研究所资料, 1985年3月.
- [31] 彭瑞祥: 汉字知觉与机器识别, 中科院心理学研究所资料, 1985年3月.
- [32] 盛焕坤等: 浅谈机助编码, 上海交通大学计算机系资料, 1983年.
- [33] 许家福: 对汉字编码研究中几个问题的认识, 计算机研究与发展, Vol. 19, No. 1 pp. 41—46, 1982.
- [34] 赵珀璋: 联想处理技术概述, 计算机工程与设计, pp. 21—32, 1982.
- [35] 松本睦: 汉字数据输入动向, 日本海外信息合作中日第四次信息合作技术友好代表团演讲录译文集, 1983年7月.
- [36] 叶津民: 拼音中文——电子机的自然语言, 同[11], pp. 48—62.
- [37] 叶津民, 袁晓四: 拼音中文——音调制自然语言, 同[11], pp. 238—258.
- [38] 顾德义: 汉字树形结构中文字母编码法, 计算机研究与发展, Vol. 20, No. 12, pp. 52—56, 1983.
- [39] 肖忠义等: 汉字字素编码法, 计算机技术, No. 2, pp. 54—62, 1983.
- [40] 钱伟长: 汉字宏观字形编码, 上海工业大学资料, 1985年5月.
- [41] 栗兴民: GZ-2汉语调字二元编码方案可行性论证报告, 河北邯郸市峰峰矿区第一小学, 1985年1月.
- [42] 汉字键盘输入方法评测试行规则, 中文信息研究会汉字编码专业委员会第二次学术交流会, 福州, 1985年5月.
- [43] 杨育超: 一九八四年上海汉字编码评测总结, 同[42].
- [44] 林东海等: 汉字输入编码的评测, 中国船舶工业总公司第709所软件开发中心资料, 1985年.
- [45] 袁仁文, 陈良志: 中文电脑输入方法的春秋战国, 资讯与电脑(台湾省), 1983年7月.
- [46] 周海令: 低熵树形声编码原理探讨, 上海电子计算机厂资料, 1983年3月.
- [47] 余明江: 汉字的“形声编码”方法, 浙江镇海县食品公司资料, 1983年.
- [48] 许汉杰: 音形数字码方案, 石家庄铁路分局电子计算机所资料, 1982年10月.
- [49] 蒋子刚: 音形信息叠码, 某部63所资料, 1983年.
- [50] 孙钧德: 《汉字基本知识》, 河北人民出版社, 1980年.
- [51] 胡裕树: 《现代汉语》, 上海教育出版社, 1981年.
- [52] 日本汉字信息处理技术, 中国长城工业公司赴日汉字信息处理技术考察组资料, 1980年3月.
- [53] 唐治和, 皮智冠: 汉字音笔触输入设计方案, 四川永川县城建设环保局资料, 1984年11月.
- [54] 邵俊夫: 汉字字形编码法, 无锡电子计算机厂资料, 1985年2月.
- [55] 陈明: 音形分合码输入系统, 上海印刷技术研究所资料, 1985年3月.
- [56] 赵珀璋: 中文信息处理系统的内部处理码, 待发表.
- [57] 中华人民共和国国家标准: GB5199.1~5199.2-85“信息交换用汉字16×16点阵字模集及数据集”, 技术标准出版社, 1985年.
- [58] 中华人民共和国国家标准: GB5007.1~5007.2-85“信息交换用汉字24×24点阵字模集及数据集”, 技术标准出版社, 1985年.
- [59] 中华人民共和国国家标准: “信息交换用汉字32×32点阵字模集及数据集”, 待审定.
- [60] 北京大学计算机科学研究所和山东潍坊电子计算机厂: 计算机—激光汉字编辑排版系统, 廊坊控制机研制报告, 1985年5月.
- [61] 王造等: 高分辨率汉字字形的放大和缩小技术, 计算机学报, Vol. 7, No. 6, pp. 410—426, 1984.
- [62] 程民德等: 《图象识别导论》, 上海科学技术出版社, 1983年.
- [63] 张维平等: 通用汉字输入编码模块, 待发表.
- [64] 楼世博等: 《模糊数学》, 科学出版社, 1983年.
- [65] 贾仲雄: 《模糊数学及其应用》, 天津科学技术出版社, 1983年.
- [66] 陈始源: 《模糊数学》, 华中工学院出版社, 1984年.
- [67] 洪峨生: 汉字识别的一种笔迹抽取方法, 厦门大学计算机系资料, 1982年.
- [68] Mao-Che Shi et al.: A Speaker Dependent Mandarin Speech Recognition System, Proceedings of the 1985 International Conference on Chinese Computer, February 26—28, 1985, San Francisco, pp. H-1. 1—1.7.
- [69] Douglas-Van Ziegler: A Microcomputer-Based System for Producing Highly-Intelligible Chinese Speech, Proceedings of the 1985 International Conference on Chinese Computer, February 26—28, 1985, San Francisco, pp. E1. 0—E1. 13.

- [70] C. T. Chang et al.: A Study on Chinese Speech Synthesis in Time Domain by Spell-to-Speech Module, Proceedings of the 1985 International Conference on Chinese Computer, February 26-28, 1985, San Francisco, pp. E2.1.
- [71] Xu Jin-Pei et al.: Microcomputer-Based Chinese Speech Recognition, Proceedings of the 1985 International Conference on Chinese Computer, February 26-28, 1985, San Francisco, pp. E4. 1-4. 13.
- [72] K. C. Chang & C. C. Yang: A Real-Time Pitch Extraction and Four-tone Recognition System of Mandarin Speech, Proceedings of the 1985 International Conference on Chinese Computer, February 26-28, 1985, San Francisco, pp. J-1.1.
- [73] Chorkin Chan: Intonation recognition of discrete utterances in mandarin, Proceedings of 1982 International Conference of the Chinese-Language Computer Society, Washington, Sept, 1982, pp. 113-121.
- [74] Rosa W. Lee & Ching Y. Suen: Distribution of mandarin initials and finals and their representation, *ibid* (73), pp. 122-132.
- [75] Chi-Chang Lee & Hung-Wei Hsu: Speaker-independent recognition of chinese characters, *ibid* (73), pp. 133-143.
- [76] Qichao He: An experiment in chinese speaker identification, *ibid* (73), pp. 144-154.
- [77] Yu Tie-Cheng: Voice input to computers, *ibid* (73), p.155.
- [78] C. H. Chen et al.: Computer speech synthesis and recognition of chinese language based on the Initial-final model, *ibid* (73), p.156.
- [79] Samuel C. Lee et al.: Microcomputer-generated chinese speech, *ibid* (73), pp. 157-168.
- [80] L. R. Rabiner & R. W. Schafer: Digital Processing of Speech Signals, Prentice-Hall, Inc., 1978.
- [81] Chin-Sung Tang: On the problem of inputting chinese characters, *ibid* (73), pp. 169-177.
- [82] H. C. Tien: A pinyin-based computer-chinese language system, *ibid* (73), pp. 178-190.
- [83] Jung-tao Hsieh: A chinese input processor phonetic symbol spelling and character selection, *ibid* (73) pp. 203-216.
- [84] S. Y. Lo: Theoretical limit on the shortest possible input codes for chinese characters, Proceedings of the 1985 International conference on Chinese Computing, San Francisco, February 26-28, 1985 pp.A-3. 1-3.9.
- [85] Zwi Barnea & Shui-Yin lo: A simple stroke ordering code and its analysis, Proceedings of 1983 International Conference on Chinese Information Processing, Vol. 1, Beijing October, 12-14, 1983, pp.120-132.
- [86] H. R. Hwa et al.: A new chinese coding method, *ibid* (85), pp. 176-193.
- [87] C. C. Lee & C. S. Chou: Structure analysis and coding of chinese characters, Proceedings of International Computer conference: Hong Kong 1980, October 12-15, 1980, p.2.1.
- [88] T. Y. Kiang & T. H. Cheng: The analysis of chinese characters in terms of basic components, *ibid* (87), p. 2. 2.
- [89] Y. X. Gu et al.: Application of a multilayer decision tree in computer recognition of chinese characters, IEEE Trans., Vol. PAMI-5, No. 1, January, 1983, pp. 83-89.
- [90] H. J. Yeh et al.: Application of LPC distance measurement to chinese speech recognition, *ibid* (87), pp. 7-2, 1-16.
- [91] Mao Yu-hang: The realization of machine recognition of handwritten chinese characters, *ibid* (73), pp. 422-432.
- [92] Mao Yu-hang: Machine recognition of chinese characters, *ibid* (87), pp. 8-1.1-1.8.
- [93] Kuoline Chai: Recognition of handprinted chinese characters by theory of fuzzy subsets, *ibid* (73), pp. 411-421.
- [94] K. L. Chai et al. The recognition of chinese characters using black pixel density for preliminary classification and amplitude spectrum of projection profiles, *ibid* (87), pp. 8-2. 1-2. 13.
- [95] Xingzhong Zhang & Ying Xia: A method of recognizing handprinted chinese characters By the extraction of an ordered sequence of the strokes, *ibid* (73), pp. 398-398.
- [96] W. Y. Kim & S. T. Bow: Preliminary investigation on the structure of Korean characters and their machine recognition, *ibid* (73), pp. 352-360.
- [97] Wen-Hsing Hsu & Fang-Hsuan Cheng: Recognition of handwriting chinese characters by stroke structure analysis method, *ibid* (84), pp. H-3. 1-3. 6.
- [98] Shu Wenhao et al.: A study on on-line handwritten chinese character recognition, *ibid* (84), pp. H-4. 1-4. 14.
- [99] Takao Suzuki: Hangeul Support System: A step to the multilingual system, *ibid* (84), pp. J3. 1-3. 21.
- [100] J. R. Ullmann: Pattern Recognition Techniques, London Butterworths, 1973.

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Medicine

OBSERVATION ON RELATIONSHIP BETWEEN MEASUREMENT OF BLOOD FIBRONECTIN AND CLINICAL COURSE OF BURNS

Beijing ZHONGHUA WAIKE ZAZHI [CHINESE JOURNAL OF SURGERY] in Chinese Vol 24 No 4, 22 Apr 86 pp 222-224, 253

[English abstract of article by Huang Wenhua [7806 2429 5478], Huang Xingyu [7806 5281 3768], and Li Ao [7821 7663] of the First Affiliated Hospital of the Third Military Medical College]

[Text] Blood fibronectin (FN) is a nonspecific opsonic glycoprotein. In the phagocytic and clearing function of reticuloendothelial system, it acts as an important component. It is one of the useful indexes for monitoring critical patients suffering from severe trauma, shock, or sepsis. This paper presents the kinetic changes of blood FN, measured by agglutination assay, in 32 cases of burned patients. The preliminary impression was that the changes of FN titre closely correlated with the conditions of patients. In early postburn period (1 st wk), blood FN reduced markedly, its level paralleled with the severity of injury. In late postburn period, drop of blood FN titre to low level indicated the development of severe systemic and/or local sepsis as well as other complications.

References:

1. 黄文华, 等. 血中纤维结合蛋白的测定及初步试用于临床病例的观察. 第三军医大学学报 1984; 6:225.
2. Lanser ME, et al. Opsonic glycoprotein (plasma fibronectin) levels after burn injury: Relationship to extent of burn and development of sepsis. Ann Surg 1980; 192:776.
3. Robbins AB, et al. Clinical response to cold insoluble globulin replacement in a patient with sepsis and thermal injury. Am J Surg 1981; 142:636.
4. Scovill WA, et al. Deficits in reticuloendothelial humoral control mechanisms in patients after trauma. J Trauma 1976; 16:898.

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15 AUGUST 1986

China Report

SCIENCE AND TECHNOLOGY



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SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

HISTORY, FUTURE OF COMPUTER APPLICATIONS REVIEWED

Beijing JINGJI RIBAO [ECONOMIC DAILY] in Chinese 5 Jun 86 p 2

[Article by Li Xianglin [2621 4382 2651]: "China's Computer Applications Begin To Open Up"]

[Text] During the period of the "Sixth 5-Year Plan," computer applications in this country developed more rapidly, and to varying degrees they have penetrated into some important fields within construction of the national economy and life in society. They have made outstanding gains, and have come across some experience that has done more for laying the foundation for the "Seventh 5-Year Plan."

Computer Applications Have Developed Quickly

While focusing on the persistent self-reliance of the party, supplemented by help from outside, and under the guidance of the policy to import advanced foreign technology to develop socialist economic construction in this country, it has now been 30 years since the initiation of the development of China's computer enterprise. Since the 3d Plenary Session of the 11th CPC Central Committee, the party and the state have made the use of computers to transform traditional industries highly strategic, and have formulated a developmental strategy for our electronics and information industries. Through the arduous efforts of the vast numbers of scientists and technicians and workers in computer applications departments throughout the country, computer applications in China have begun to open up.

Research and development projects in computer applications have developed from a few hundred achievements to more than 20,000, and applications fields have expanded quickly. From fields primarily centered in science research and national defense and in key national projects, they have made their way to varying degrees into the areas of energy, transportation, communications, metallurgy, chemical engineering, mechanics, electronics, finance, commerce, agriculture, national defense, public safety, science and technology, culture and education, physical education, and hygiene. Large scale data and service systems in areas of the national economy like information, banking, electricity networks, weather, and public safety have begun building up and have had a good start.

In 1980 there were some 2,900 computers that were not microcomputers installed throughout the country, with only some 600 microcomputers. This has developed until now there are more than 7,000 non-microcomputers and more than 130,000 microcomputers. Among these, some computers of all types can handle both English and Chinese processing.

In 1980 there were only 20,000 scientists and technicians in this country involved in computers. Now, they have begun to make up a scientific and technical contingent of about 100,000 that is hierarchical and that engages in computer research, technology development, industrial production, teaching, and technical services. In addition, there are more than 5,000 teachers involved in elementary and middle school teaching and in extra-curricular activities.

In 1980 the technical base for computer applications was still quite weak, and it lacked general use supporting software and basic technical methods. Changes have been made after years of hard work, and there have been outstanding advances in the extent of applications: a quantity of supporting software has been successfully used in various systems, as well as has a number of software packages for different applications fields; work has begun on the building of multi-type databases of different scales and of economic and mathematic models; applications and theoretical methods have been researched and developed for manual seismic prospecting numerical methods; throughout the country, work has begun on basic research in researching basic information standardization and safety and security; there have been great advances in Chinese language information processing technologies, and the writing symbols for 11 nationalities, including Chinese, Mongolian, and Tibetan, are being handled by computer to varying degrees.

Computer Applications Have Played an Important Role

As the electronics and information industries in this country have shifted toward serving development of the national economy, the four modernizations, and activities throughout society, computer applications during the period of the "Sixth 5-Year Plan" have had quite marked results.

First, they have contributed to the transformation of traditional technology. Computer applications have made great contributions to the areas of improving product quality, lowering costs, improving work efficiency, as well as results, excellent products, and engineering designs, accelerating the renewal of products, and in promoting science management. According to calculations by the Planning Department of the Ministry of the Coal Industry and the actual practice of the Ministry of Water Resources and Electric Power, by using computer-aided design, funding can typically be reduced by 3-5 percent. The General Shipping Company uses computer systems to aid in the manufacture of ships, and everything from price quotations, signing agreements, design, manufacture, and inspection to paying and settling ship accounts is aided by computers. Just from reducing 1 or 2 months from the time of design alone, the general company reaped economic gains of 10 million yuan. The General Petroleum and Chemical Industrial Company used computers to transform the production and management system, economic results for which company were above 260 million yuan in 1985.

Second, initial results have been seen in overall national policy making and in management services. During the period of the "Sixth 5-Year Plan," the State Planning Commission and the State Bureau of Statistics each established databases for overall, energy, agriculture, population, personnel, and the basic conditions of medium and large core enterprises. They constructed economic and mathematic models for economic development forecasting and policy simulation, and they have provided a basis for formulation of policy and planning. During our third population survey, 40 billion characters and 1.2 billion records of data were handled. The computing center at the Ministry of Finance has used computers to do forecasts and comparisons of financial materials from 80,000 enterprises, the amount of work they have done being equal to that of 550 workers in a year, and they have provided a basis for overall policy making for the state's second phase of turning profits into taxes. The overall balance model developed by the Ministry of Astronautics for financial supplements, pricing, and wages has forecasted economic trends in overall market sales volumes and price levels for the last 3 years, which has contributed to calculating standards for vegetable supplements for the urban population. The State Supplies Bureau economic management information system in just the area of managing bearing products alone, reduced the warehouse storage quantities for the provisions organizations of various ministries and commissions by 30 percent from 1984 to 1985, cutting down funds in use by more than 200 million yuan.

Third, results have been outstanding for science and engineering data processing services. Relevant state science research organizations and higher institutions have brought in and developed linear and non-linear finite element analysis programs and three-dimensional graphics processing systems, which have been successfully used in major projects. Data processing for petroleum seismic well logging materials has reached international standards of the early 1980's. The numerical method for seismic processing that was researched by the Chinese Academy of Sciences is of great theoretical and practical value. The Ministry of the Petroleum Industry has used computers to handle seismic prospecting data and materials, which has allowed them to bring down the amount of funds needed for the verification of 100 million tons of petroleum reserves from the 790 million yuan of 1981 to the 320 million yuan of 1984. Using computers to evaluate well logging information has improved the rate of conformity by 27 percent over manual solutions, the economic results generated from this being 175 million yuan.

Fourth, they have played a very important role in national defense research and in major projects. Computer techniques such as scientific calculations, numerical simulations, emulation, and measurement have had important functions in building national defense and major project construction, as well as in developing high technology. For example, we have used computers that we have designed and manufactured to control nuclear fusion research, launching missiles into the Pacific and from beneath water, as well as for synchronous satellite positioning.

Important Experiences in Applications

Dramatic focus on microcomputer applications is an important path by which to make breakthroughs in our computer applications.

Practice has shown that microcomputer applications are inexpensively financed, produce quick results, and are beneficial to the training of applications personnel. They are easy to operate and easy to disseminate within this country. Therefore, they are also useful for getting rid of the superstitions people have about computers, and for making the most of enthusiasm for using computers in all professions and industries. Disseminating applications based on microcomputers is extremely suited to our national conditions, and is one of the important reasons for attaining greater development in computer applications during the period of the "Sixth 5-Year Plan."

Dissemination and application of microcomputers has resulted in an accumulation of experience that has made necessary technical and methodological preparations for the full utilization of the hardware and software resources of non-microcomputers.

Dissemination of model demonstration industries is an effective method for the active but prudent development of computer applications, that deals with the complexities of computer applications, and is a scientific method that has come about in light of actual conditions in this country. The method that has resulted from a summation of the experiences of many areas and sectors is: 1, to proceed after an evaluation of strengths; 2, be familiar with the technology; 3, cater to production and obtaining results; 4, on the basis of experimental sites and after results have been obtained, then continue to disseminate progressively within particular fields or industries.

Enhancing software development and circulation control is the key to doing a good job with computer applications. The research and development of systems software and support software is the basis for universal applications in the dissemination of computer applications. Some departments and units have had outstanding results from joining together to bring about technical advantages and to concentrate development. Applications software have joined the areas of science research, education, the computer industry, and users, and have undertaken development based on the realities of professional applications. Many valuable achievements in dissemination have resulted from this, which have promoted the commercialization of software and have given impetus to applications.

Training personnel through the use of various channels and methods is an important path for expanding the computer applications contingent. To develop computer applications, we must build a technical contingent that is clear in hierarchy and fully equipped with hardware. Under the unified leadership of the State Education Commission, invoke the enthusiasm of all sectors, and train personnel through various channels and with various methods. In addition to formal education, many schools and applications departments have started various kinds of study classes that have trained a large number of applications personnel.

Based on actual conditions in this country, the integration of computer specialists with user specialists in other fields is a most positive factor in promoting computer applications. The combination of two kinds of talent and two kinds of knowledge suits our rational condition, suits the requirements of knowledge intensiveness for computer applications, and suits the trends in international science and technology that develop toward a high degree of comprehensiveness. This kind of integration makes it easy to pool collective wisdom and develop new thinking, and provides preparations in the area of talent for developing a computer manufacturing industry and a computer servicing industry. It also plays an important promotional role in forming a Chinese information industry.

12586

CSO: 4008/1080

PERFORMANCE OF V-TYPE FLAMEHOLDER IN AFTERBURNER IMPROVED

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 7, No 2, May 86 pp 179-181

[Article by Tan Yaoyuan [6151 3185 0337] and Wang Jiahua [3769 1367 7520], Nanjing Aeronautical Institute: "A Test Research for Improving the Performance of V-Type Flameholder Used in an Afterburner"; this paper was read at the Fifth Academic Annual Meeting of the Chinese Engineering Physics Society held in Suzhou in 1985]

[Text] English Abstract: This research paper describes the V-type with gaps flameholder used in a jet engine afterburner. It was the result of model tests that the recovery coefficient of total pressure increased, the quenching limit for poor fuel extended and the combustion efficiency improved. The unit fuel consumption rate decreased about 1 percent under full scale engine tests.

I. Test Equipment

The test equipment was a low pressure combustion system with a total air flow of 1.4 kg/s. Fuel feed was in two locations: a fuel injection rod placed at the front about 3 meters from the holder, with the fuel accounting for 70 percent of the fuel volume, this fuel could completely evaporate; and a single centrifugal nozzle placed at the back which accounted for 30 percent of the fuel and since it was close to the holder, the fuel could not completely evaporate. This fuel feed method could approximate the actual fuel feed situation in an engine. The test section had two elements: height x width = 150 x 100 mm². The test was to open gaps on the tops of conventional V-type holders to turn it into a simple preheating holder. The blockage ratio was 30 percent. The structure is as in Figure 1.

II. Model Test Results and Discussion

1. Losses due to flow resistance. In cold air tests, we measured the relationship of the holders' total pressure recovery coefficient number and the rate of flow M number, see Figure 2. $\sigma_b = P_2^*/P_1^*$. P_2^*/P_1^* is the total pressure of the front and back of the holder. Figure 2 gives the normal objective pattern. The total pressure recovery coefficient of the improved-type holders were higher than the conventional ones, and became higher with

increases in the gap width. The higher the speed, the greater the sensitivity of the gap width to the total recovery pressure coefficient. The total pressure recovery coefficient of a $2\delta = 6$ mm holder when $M = 0.2$, increased 0.5 percent compared to the conventional V-type. This structure can be viewed as a combination of a small V-type holder and a pressure expander. As the gap increased, the blockage of the small holder diminished, therefore the losses diminished.

Holder Number	No. 1	No. 2	No. 3	No. 4
Gap width 2 δ mm	0	4.14	6.18	10.40

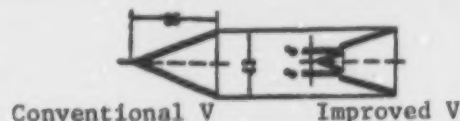


Figure 1. Flameholder Structure and Dimensions

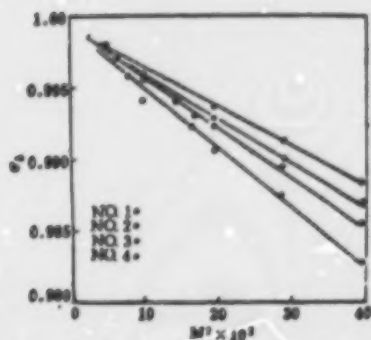


Figure 2. Relationship of Total Recovery Coefficient and M Number

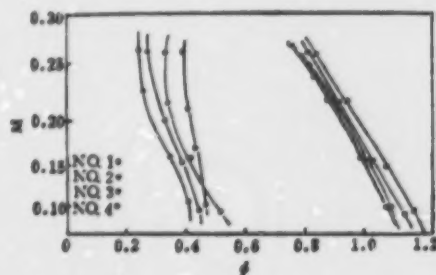


Figure 3. Graph of Quenching Limit

2. Stability. See Figure 3 for test results of the quenching of poor fuel-good fuel limit. When the M number increased, the poor fuel quenching limit grew wider; the poor fuel range of the improved type holder was broader than the original type, and in No 2 holder is even clearer. When $M = 0.25$ the quenching limit expanded from $\phi = 0.4$ to $\phi = 0.25$, an increase of approximately 37.5 percent. Since the back nozzle was closer to the holder, two phase mixed gases entered the holder. An increase in the M number helped atomizing. The two phase mixed gases enter the holder from the gaps, the fuel drops are concentrated in the backflow area and evaporate and burn, which are characteristic of evaporation type holders and preheated type holders, therefore the quenching limit expanded. The No 4 holder's

$2\delta = 10.4$ mm, the preheated flow was too great, the backflow area contracted, and only the small holder played a role stabilizing the flame. Performance began to decline. On the good fuel limit, the range of the improved-type was contracted more than the original type, but the degree of contraction was not great. If $M = 0.25$, the good fuel quenching range dropped from $\phi = 0.87$ to $\phi = 0.81$, a contraction of about 7 percent. This is because when the two phase flow evaporates in the holder, the ratio of some of the fuel and air surrounding the fuel drops is richer than in the conventional holder. Figure 4 shows that the good fuel quenching range becomes slightly narrower as the gap width increases but the range of the poor fuel quenching limit first expands as the gap increases, then contracts. Within the range of $2\delta = 4-6$ mm the poor fuel quenching limit is optimum.

3. Combustion efficiency. The combustion efficiency of the holders with changes in the quantity ratio are as in Figure 5. The combustion efficiency of the improved holder was about 5 percent higher than that of the conventional one. These curves have the typical characteristics of evaporation-type holders. When the equivalent ratio is larger than a certain value (such as 0.63) then as the gaps become wider the volume of fuel which is not yet evaporated which has entered the holder increases and efficiency drops; conversely, when a large gap holder in ϕ is relatively short, the combustion efficiency is higher. When $\phi = 0.7$, and 2δ is between 4 mm and 6 mm, the combustion efficiency is at its optimum value.

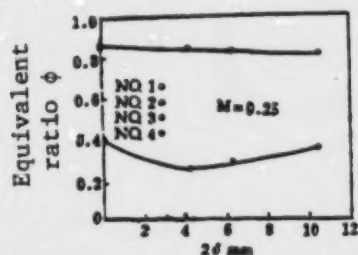


Figure 4. Quenching Limit With Changes in Gap Width

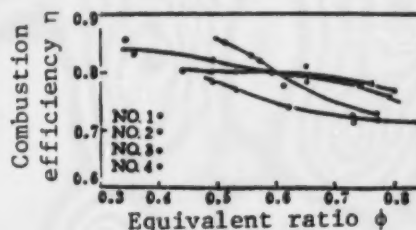


Figure 5. Relationship of Combustion Efficiency and Equivalent Ratio

III. Bench Tests

A WP-6 engine was used for all dimension tests of the holder. No 11 holder's $2\delta = 6$ mm and No 15's 2δ was 8 mm. Data on the comparison with the original type is listed in Table 1. dC is the difference between the engine's unit fuel consumption and the standard unit fuel consumption ($dC = C_T - C_{\text{standard}}$), dR is the difference of engine measured thrust and the standard thrust. From the rated state we can see that when the thrusts are basically equivalent, No 11's holder unit fuel consumption drops 0.009 [kg of fuel/kg of thrust·hours]. The drop in No 15's test was even greater because the gaps were large and the loss due to flow resistance was small; the results of No 11's afterburning state were more satisfactory, thrust increased 35 kg,

fuel consumption dropped 0.009 [kg of fuel/kg of thrust·hours], because the better dimensions of the model test results were selected for this test. Afterburner thrust was about 3000 kg, therefore each engine could save 27 kg of fuel per hour. If the adjusted afterburner thrust is equivalent to the original model, fuel consumption can still be lowered. The relative gain in fuel consumption is about 1 percent. From the temperature indicating paint it was determined that the holder wall temperature was about 50°C lower than the original model. This is the result of gap air flow cooling which is beneficial for prolonging holder life.

Table 1. Comparison of Bench Test Results

Status	Original V-type			No.11			No.15		
	Rated	Max.	(1)	Rated	Max.	(1)	Rated	Max.	(1)
Meas. RPM	11155	11150	11155	11156	11143	11160	11150	11140	11155
$dR(\Delta_R)$, kg	-7.5	-28	-15	-10 (-2.5)	-23.6 (+4.4)	20(+35)	-6(+1.5)	-38(-10)	25(+40)
$dC(\Delta_c)$, kg/kghrs	-0.0105	-0.0210	-0.0907	-0.0195 (-0.009)	-0.0245 (-0.0035)	-0.0997 (-0.009)	-0.0291 (-0.0186)	-0.0238 (-0.0028)	-0.0902 (+0.0005)
$T_2, ^\circ\text{C}$	540	630	645	536.6	631.7	650	535	625	650
Jet dia. mm	480	451	508.5	473	448.5	506	473	448.5	506

Note: Fuel consumption gain $\Delta_c = dC_{\text{improved}} - dC_{\text{original}}$; thrust gain $\Delta_R = dR_{\text{improved}} - dR_{\text{original}}$

Key: (1) Afterburner

IV. Preliminary Conclusions

The flow resistance of the improved holder was lower than the original model. When M is 0.2, the overall pressure recovery coefficient increased 0.5 percent; the good fuel quenching limit contracted about 7 percent but the poor fuel quenching limit expanded about 37 percent; relative comparative combustion efficiency increased about 5 percent; optimum gap width 2δ was 4-6 mm; in engine bench tests, in rated and afterburner states it could lower unit fuel consumption about 1 percent.

The author expresses his profound thanks to Comrades Cao Guoming [2580 0948 0682], Wang Jigen [3769 4764 2704], Zhang Hongbin [1728 3163 6333], and Su Xianru [5685 0341 1172] who participated in the tests.

8226/6091

CSO: 4008/73

APPLIED SCIENCES

PRESSURIZED COMBUSTION TEST OF COAL-WATER MIXTURE AS GAS TURBINE FUEL

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 7, No 2, May 86 pp 162-165

[Article by Gao Lijun [7559 7787 0689], Institute of Engineering Thermophysics, Chinese Academy of Sciences: "A Pressurized Combustion Test of Coal-Water Mixtures as a Fuel in Gas Turbine Combustor"; this paper was read at the Fifth Scientific Annual Meeting of the Chinese Engineering Physics Society held in Suzhou in 1985]

[Text] English Abstract: The purpose of this paper is to examine the feasibility of Ultra-Cleaned Coal-Water Mixture (UCCWM) as a fuel in a gas turbine combustor. Five kinds of UCCWM were used in pressurized combustion at 4×10^5 Pa, 7×10^5 Pa, and 11×10^5 Pa. The effect of combustor pressure on combustion efficiency, distribution of temperature, particle size, ash deposition, and gas exhaust was discussed. A viability of using CWM in modified aero-engines is being evaluated under atmospheric pressure.

This paper treats the feasibility of using ultra-cleaned coal-water mixture in gas turbine combustors. The cleaning process of ultra-cleaned coal-water mixture should be higher than in boilers, the average dimensions of the particle bodies in the mixture is on the order of 10 μm , ash and sulphur content is about 1 percent (by weight). This paper analyzes the pressurized combustion of five different ultra-cleaned coal-water mixtures at 4×10^5 Pa, 7×10^5 Pa, and 11×10^5 Pa and emphasizes a discussion of the influence of pressure on combustion efficiency, wall temperature distribution, dimensions of particles in the exhaust gas, ash deposition, and gas exhaust, and describes the constant pressure combustion experiments using coal-water mixture made by Shandong's Datong Coal.

I. Important Constituents and Characteristics of Ultra-Cleaned Coal-Water Mixture

Table 1. Constituents of Ultra-Cleaned Coal-Water Mixture

Mixture number	Elemental analysis (% by weight)						Water (% by weight)	Appx. analysis (% by weight)		
	Carbon	Hydro-gen	Oxygen	Nitro-gen	Acid	Ash		Vola-tile matter	Fixed carbon	Ash
S1	76.45	4.73	12.97	1.84	1.00	3.01	36.18	36.53	60.46	3.01
S2	77.61	4.91	13.35	2.19	1.26	0.68	39.01	36.75	62.57	0.68
S3	78.56	4.95	11.62	1.55	1.12	2.20	41.40	37.53	60.27	2.20
S4	82.44	5.12	8.53	1.62	0.91	1.38	37.96	--	--	--
S5	82.44	5.28	7.74	1.86	1.0	1.13	35.51	--	--	--

Table 2. Characteristics of Ultra-Cleaned Coal-Water Mixture

Mixture number	Viscosity (cp)	Shear rate (s^{-1})	Maximum particle diameter (μm)	Average dia. of particle (μm)	Thermal value of coal (J/kg)
S1	889	2.5	40.3	5.27	31×10^6
S2	3,340	1.5	32	7.11	31.62×10^6
S3	331	2.5	40.32	6.12	31.8×10^6
S4	--	--	--	--	--
S5	--	--	--	--	34.33×10^6

II. The Pressure Combustion Test System

1. Shipping the mixture: Before feeding, the mixture flowed by gravity from the storage tank to the pump and the pump also constantly forced the mixture into the storage tank so that it constantly circulated to obtain a good flow of the mixture. The volume of mixture flow was regulated by regulating the air pressure entering the tank. 2. Atomizer: An anti-equilibrium twin channel pneumatic nebulizer was used in the test for the atomizer. See Figure 1 for a diagram of the structure of the nozzle head. Air is the atomizing medium. To avoid blocking of the mixture, a straight mixture channel is placed in the center of the nozzle. The natural gas channel is for preheating the combustor. The rotational direction of the atomizing air is the reverse of the mixture flow rate. 3. Cyclone: In the tests we used a slider cyclone to provide primary swirling air. Primary air flowing from the adjustable channel accompanied by secondary swirling air in the

reverse direction intensified the mixture of air and mixture in the combustor and formed a violent backflow area which promoted the combustion process. The maximum vortex number corresponding to when the maximum adjustment angle is 15° is 1.37. The air was preheated to 250°C – 350°C . Preheating the air promotes evaporation of the water in the coal-water mixture and thus promotes ignition and a stable flame. 4. Combustor: The combustor with refractory cement lined walls is illustrated in Figure 2. It is made up of a central cylinder with a high speed area. An electrospark ignition fires the natural gas and when the walls are preheated to 1000°C , the burning natural gas is replaced by burning coal-water mixture. The smoke goes through a high temperature control valve and a water-quenching ring then is released into the atmosphere by an exhaust fan. The exhaust temperature dropped to about 150°C . The combustor pressure relies on guarantees of inputting an air and coal mixture at a definite pressure and regulating the high temperature control valve of the exhaust system is the way in which stability of pressure is achieved. 5. Measurement system: A thermocouple was used to measure the combustor wall temperature. Combustion efficiency was determined by measuring the CO_2 and O_2 in the combustion product. A quench sampling tube was used to collect smoke and a counter was used to determine the dimensions of the particles in the smoke.

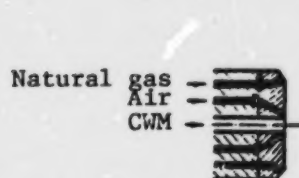


Figure 1. Atomizer Throat

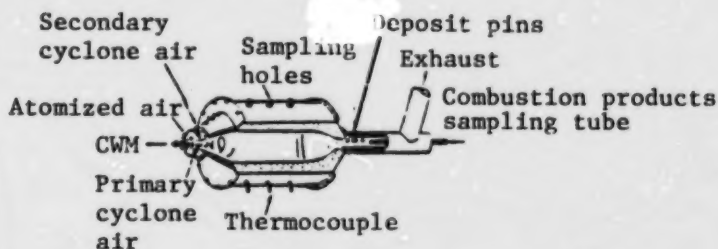


Figure 2. Combustor

III. Main Test Results

The tests were carried out on the basis of a series of selected parameter tests. Test parameters chosen through analysis and comparison are as follows: coal mixture flow was 45 kg/h, the excess air coefficient was 25 percent, the mass/flow ratio of atomized air to coal mixture was 3, the primary air cyclone number was 1.37, the flow distribution ratio of primary cyclone air to secondary cyclone air was 1:1. The main test results are as follows:

1. Combustion efficiency: Generally speaking, when fuel at a definite mass flow and air at a definite mass flow is supplied at different pressures in a gas turbine combustor, the temperature in the combustor does not basically change, thus it is held that the mass flow rate of air is directly proportional to pressure, therefore when the pressure is high there should be a high flame density and combustion rate, and when the pressure is high the flame temperature should be higher than when the pressure is low.

After the fuel is ignited a high radiation temperature is created, therefore the particle surface also should have a high temperature, and generally speaking, combustion efficiency at high pressure is higher than at low pressure. But on the other hand as pressure increases, the convection heat transfer of the particle surface to the surrounding air also increases^[2], thus making the temperature of the particle surface lower, leading to a lowering of combustion as a whole. For burning the coal-water mixture, as pressure increases, reciprocal jietuan [4814 0957 aggregating?] of the particles is created thus reducing the overall combustion area which can also lead to lowering total combustion. The combustion efficiencies given in Figure 3 are average values. From the figure it can be seen that as pressure increases, the combustion efficiency is lowered, and when burning S4 mixture, the lowering of efficiency is most obvious.

2. Particles in the gas: Figure 4 gives the average diameter of the particle bodies in the smoke of different types of ultra-cleaned coal-water mixture at different pressures. The sampling tubes at positions #1, #2, and #3A(#3B) were located 13 cm, 33 cm and 53 cm, respectively from the combustion head flange surface. From the figure it can be seen that the diameter of most of the particles is between 10 μm and 20 μm and this value is larger than the diameter of the particles in the coal-water mixture. This is different from the situation of using constant pressure combustion of the same nozzle. At constant pressure, after the ultra-cleaned coal-water mixture has burned, the average diameter of the particles in the smoke is only one-half the average diameter of the particles in the coal mixture^[3], so it can be seen from this that as the combustor pressure increases, the small particles jietuan together. From Figure 4 it can also be seen that as the coal-water mixture viscosity increases, the particle dimensions also increased, for example, the particle diameters of mixtures S2 and S5 which had a viscosity of about 3000CP were larger than S4 which had a viscosity of 331CP. From the figure it can be seen that at different sampling positions the changes in particle dimensions were not uniform either, not only because of the pulsation of combustion, but also due to sampling chance rate, and although during the tests there were sampling tubes at different cross-sections, a single point sampling tube can only obtain a sample at one (or two) point(s) on each surface.

3. Temperature: Figure 5 shows that when burning different types of ultra-cleaned coal-water mixture, the combustor exit wall temperature reached over 1180°C. The rise in temperature again at the 7th point in the figure indicates that when burning the coal-water mixture the flame is elongated. Therefore, when designing the combustor, sufficient combustor length and displacement and good air flow should be considered to achieve even higher complete combustion and combustor exit temperatures.

4. Discharge of combustion products: Figure 6 shows that in the combustion product the range of SO₂ was 450-570 ppm, the range of NO_x was 330-720 ppm. These values do not yet reach the U.S. national discharge standard.

5. Ash: The overall ash content in the combustor was low. For example, when burning S2 at 4.2×10^5 Pa, the total amount of mixture fed was 86 kg, and after the test, 325 mg of ash were collected in the combustor, only 0.38 percent of the amount of mixture fed, therefore most of the ash was expelled with the smoke.

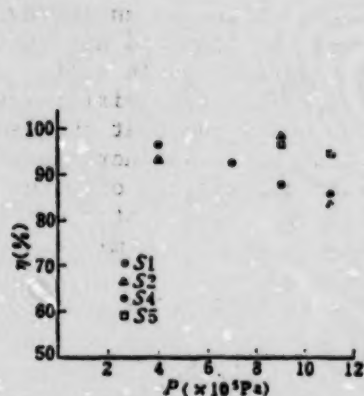


Figure 3. Combustor Efficiency

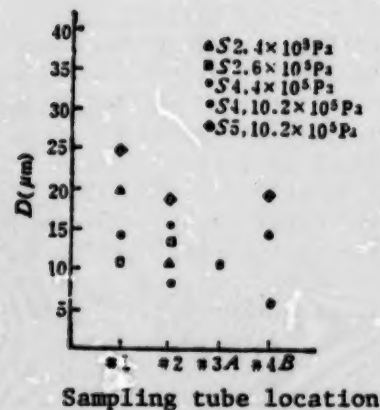


Figure 4. Average Diameter of Particle Bodies

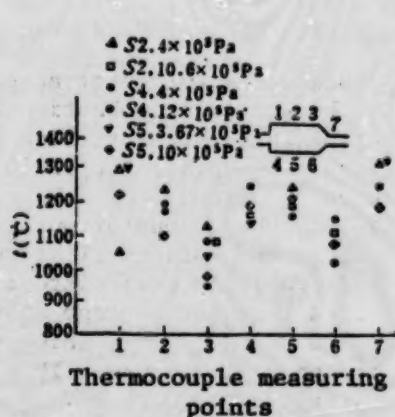


Figure 5. Wall Temperature

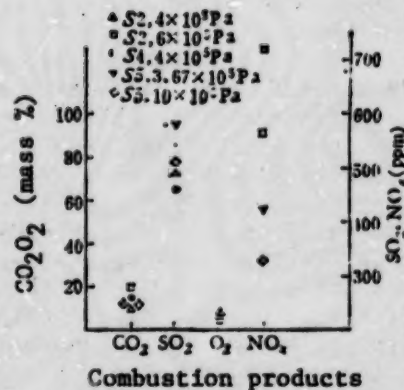


Figure 6. Composition of Combustion Products

IV. Constant Pressure Combustion Tests Carried Out in China*

We first carried out constant pressure combustion tests of the application of coal-water mixture to gas turbines in China in 1984. The combustor was an improved WP-5 aero-engine combustor and a pneumatic nebulizer nozzle was used to replace the original pressure centrifugal nozzle; taking into account that the spray distance of burning the coal-water mixture was longer, the four exhaust holes in the front of the flame tube were sealed; to increase the radiation of the flame tube inner walls, they were sprayed with Al_2O_3 . See Table 3 for the parameters used in the test. The test showed that when there was a small amount of auxiliary ignition methane flame present,

*This work was carried out by the Application of Coal-Water Mixture to Gas Turbine Research Group of the Engineering Thermophysics Institute

the coal-water mixture could form torch stable combustion inside an improved aircraft gas turbine combustor. If we used oxygen as the injected gas in the nozzle, after the auxiliary ignition methane was cut off, a single coal-water mixture torch could maintain stable combustion. When the swirler was improved from the viewpoint of turbulence theory, we could see that the length in the flame area was clearly reduced, combustion intensity was increased, and at this time after the auxiliary ignition methane gas was cut off, the injection gas in the nozzle was switched from oxygen to air, and stable combustion by the single coal-water mixture torch was achieved in 16 minutes.

Table 3. Constant Pressure Combustion Test Parameters

Coal-water mixture flow	20 kg/h
Cold air flow	0.048 kg/s
Combustor inlet air temperature	873°C
Injected air flow	0.0017 m ³ /s
Injection methane gas flow	0.00034 m ³ /s
Supplemental air flow	0.0024 m ³ /s

V. Conclusion

1. In the pressure combustion test bed with a heat tolerant layer adapter, when the nominal input heat was 0.737×10^9 J/h, the pressure combustion tests showed that the use of ultra-cleaned coal-water mixture in gas turbine combustors is feasible. When the coal-water mixture is burned below 12×10^5 Pa (meter pressure), most of the efficiency is above 90 percent. 2. When the excess air coefficient in the combustor is 1.2-1.4, the combustor outlet wall temperature reached more than 1180°C. 3. For the anti-equilibrium pneumatic nebulizer nozzle, when the atomized air ratio to coal mixture flow is 3, the pressure combustion tests indicated that the average diameter of the particle bodies in the smoke was between 10 μ m and 20 μ m, which value is larger than the diameter of the particles in the coal mixture. This indicates that at high pressure the particles jietuan together. 4. Although fairly stable combustion was achieved in the pressure combustion test bed, the discharge of SO₂ and NO_x is not up to U.S. national standards. 5. Exploratory constant pressure tests of burning coal-water mixture carried out in China in light structure improved gas turbine aero-engine combustors similarly proved the feasibility of burning coal-water mixture in gas turbines.

REFERENCES

- [1] Wang Yingshi et al., "A Thermodynamic Analysis of the Gas Turbine/Steam Turbine Combine Cycle With CWS as Fuel," Proc. of 5th Int. Symposium on Coal Slurry Comb and Tech., (1983).
- [2] T.T. Omori and A.A. Orning: "Effect of Pressure on the Combustion of Pulverized Coal," ASME Transaction, 72, (1950).
- [3] Debbie M. Davis-Watermire and Rodney J. Anderson: "Combustion Research Related to Utilization of Coal as Turbine Fuel," METC Research Paper, (1983).

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SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

LIAOWANG HAILS ATOMIC BOMB SPECIALIST DENG JIAXIAN

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[Article by LIAOWANG reporter Gu Mainan [7357 6701 0589]: "Deng Jiaxian, a Man of Great Merit in Developing the 'Two Bombs'"]

[Text] Many scientists of the older generation still remember that for some time during the 1940's, a number of outstanding nuclear physicists in the world "disappeared" all of a sudden. And they did not reappear in public until the successful explosion of the first U.S. atom bomb.

Scientists "disappeared" in China, too. Not long ago, Professor Yang Chen Ning asked a 1960's nuclear physics graduate at Beijing University: "Have you ever heard of Deng Jiaxian?" The latter shook his head. We cannot blame that graduate for his ignorance. This is because Deng Jiaxian had for a time engaged in some kind of top secret work for the state.

This reporter has of late covered China's nuclear weaponry research and design base, and has learned much about the heartbreaking stories of Deng Jiaxian and many other unknown heroes, who have dedicated their whole lives to consolidating China's national defense.

We Shall Launch a "Big Firecracker"

We will go back to autumn 1958. A responsible person of the Second Ministry of Machine-building at that time sent for Deng Jiaxian and said: "Deng, we shall fire a 'big fire-cracker.' This is a top secret matter, and we should like you to join in the work. What do you think of it?" He said solemnly: "This is a glorious task!"

Deng Jiaxian had been to the United States before the founding of the PRC, shortly after his graduation from the Department of Physics, Southwest Union University, Kunming. After he acquired his doctorate degree at Purdue University, Indiana in 1950, he overcame one obstruction after another and returned to China with another 200 or more Chinese students studying abroad. When this young doctor appeared before the older generation physicists who had just returned from Europe and the United States, such as Qian Sanqiang, Peng Yuanwu, and Wang Ganchang, everybody was happy to have such young blood at the newly set up Modern Physics

Institute for Research under the Chinese Academy of Sciences. For several years, Deng Jiaxian worked hard together with the veteran scientists in initiating the undertaking. They rode their bicycles to purchase parts at some stalls selling secondhand goods, and made the Modern Physics Institute--the first research organ of modern physics in new China--gradually grow.

When the responsible person in China's nuclear industry said that China was to launch a "big firecracker," and that Deng was to join in the work, Deng instantly understood that he was being asked to take part in the research and development of the atom bomb. Facing this matter of great importance as well as arduous and glorious, he was rather terrified and timid, and said: "Developing the atomic bomb! But, am I up to the requirements for the job?"

"Sure, you are. Do it together with the others! This is the nation's trust in you. The whole thing has a bearing on the security or danger to the state; I believe you will make a good job of it!"

When Deng went home that evening, he could not sleep all night. His wife, Xu Luxi found this extraordinary and asked him what had happened?

"No big deal, only I'll be transferred to another post!" he said quietly, but when he thought that it would be impossible to stay together with his wife and children most of the year round, he was a bit sad. With deep regret, he said: "Luxi, I'm afraid I shan't be able to take good care of our day-to-day family life from now on. My life will be dedicated to my future work. If I do a good job of it, my whole life will be quite significant, and it is even worthwhile if I die for it!"

That night, Deng and his wife recalled many things in the past, talked about the experiences they had shared and the future of the nation, and both of them became emotional. His wife Luxi, the eldest daughter of Mr Xu Deyan, knew nothing about where Deng would be transferred, nor what kind of job he would be engaged in. She saw that the undertaking her husband would go in for would be an important one that had a bearing on the state's interests, and believed that her husband would go all out without regard for his own life. That was because they had both experienced national disasters and the ruin of their families...the gunfire of the Japanese invaders at Lugougiao in the 'July 7 incident' in particular seemed to be still echoing in their ears, and how often did the scenes of Japanese soldiers arbitrarily slaughtering unarmed Chinese come back before their eyes...

"A nation without the strength of self-defense will inevitably be knifed, and its people will suffer." Since the "July 7 incident" Deng had to begin a life in exile with his teachers and schoolmates. Now, when he learned that China, a backward country which had been bullied arbitrarily was going to develop a strategic nuclear weapon in order to consolidate its national defense he could not repress the excitement and joy in his heart. Since then, this excellent young physicist, who had already caught the attention of the public both at home and abroad, receded totally into oblivion.

Years of Hardship Initiating the Undertaking

After his "disappearance," Deng Jiaxian entered the Nuclear Weaponry Research and Design Institute in preparation. The so-called Nuclear Weaponry Research and Design Institute at that time was simply a stretch of farmland, and its scientists and technicians were few in number. As responsible person for the theoretical design of the atom bomb, he had to start everything from scratch. The first thing he did after he took office was to change into his overalls, and to work together with the construction workers, cutting down kaoliang, building earth works, pushing carts, mixing mud, and building houses. He worked side by side with young people in mud and water. College students admired this hard-working man with a doctorate degree from a university abroad. When they saw him work clumsily, with his tall and broad physique, they found this funny and nicknamed him "the bear," and forgot about his official title. It was very busy at the work site; and the scientists and technicians were sweating all over. As days went by, one building after another was erected for the research center and workshops.

Prior to this, Marshall Nie Rongzhen had signed an accord on behalf of the Chinese Government on new national defense technology with the Soviet Union. According to the accord, the Soviet Union promised to provide China with an atom bomb model for teaching purposes. They had done a lot of work for the exhibition of this model, and sent people to the station for its delivery on several occasions, but the model never appeared.

One day, Liu Jie, the vice minister of the Second Engineering Building Ministry sent for [Deng Jiaxian] and said: "You must be mentally prepared; we must rely on ourselves for the theoretical design of the atom bomb."

That happened in the late 1950's.

"The research and development of a strategic nuclear weapon is where the interests of the Chinese and the world's peoples lie; now we have to rely on ourselves!" He was addressing the young college students. He encouraged the young people around him by saying: "People like us who are engaged in this undertaking should willingly become unknown heroes. We should not care about fame, nor personal benefits, but we must bear hardships. Even your fruits of scientific research are not to be published as theses."

If the atom bomb is compared to a dragon, the theoretical design of the atom bomb will be "the dragon head." According to a saying by the leading member of that time: The cubic equation for "the dragon head" is "the dragon head" of "the dragon head" of "the dragon head." The result of this leading work had a bearing on the success of all kinds of engineering design of the atom bomb. None of the Chinese had ever built an atom bomb before, and there was no authority to speak of in this field. Under the conditions of the strict blockade abroad, Deng studied hard, and prepared his lessons before giving lectures. The young people called him Professor Deng, but he said: "No don't do that, let's work together!" Sometimes,

he had to prepare his lessons until four in the morning, and he would take a rest in the office for 2 or 3 hours, then resume his work at daybreak. In the evening, the college students would all come to the office to study, but Deng would work until the others would stop their studying, despite the fact that his wife and children were waiting for him. Often he would go home on his bicycle under the escort of young people in the still of the night. Then, the gate to the barbed wire compound of his living quarters was closed, and he would climb over the barbed wire fence, and the young people would pass the bicycle to him over the fence. When he got home, he would find his wife working in the office on the evening shift, and his son asleep in the corridor... In those days, his whole energy was devoted to his work. Day in and day out, he would be in a trance, and he would think of the atom bomb even when he was walking. He worked so untiringly that many "jokes" about him circulated among those around him. One evening, they had some urgent task to complete, and when it was finally done, he said to one of his comrades, "Come, let's have a meal at my place!" When they had supper, the guest found the noodles had turned into some kind of gruel. His son had put the noodles in cold water before he put the pot on the fire!

"I'm sorry, that's my child's cooking," Deng said apologetically. Because his wife was working heart and soul in the office, their child had to do all the cooking. A primary school pupil of 12, his son had already undertaken all the household chores including preparing all the family meals.

Usually, he would never give orders to others at work, but just pat their shoulders and say: "Well, I'll have to rely on you for this, please do a good job of it." In those days, he worked overtime almost every night till midnight. Several years went by and in his planned work schedule, Sundays were always included as workdays. He had a familiar way with young people, being together with them all the time. He showed a great concern for others and was always untiring in his work. When it was at 1930 on Sundays, he would say: "All right, let's call it a day; it's time for you to go home and take care of your family affairs."

Nothing is too difficult to accomplish in this world. Deng Jiaxian and the others worked day and night, and by 1959, they had outlined the theoretical calculation of China's first atom bomb. In a series of key questions, such as explosive dynamics, neutron conveyance, nuclear reaction, the properties of material under high temperature and pressure, all kinds of scientific data had been worked out in a down-to-earth way, with no margin for error. China had none of the large-type electronic computers at that time. In order to get to the bottom of a problem, he once led more than 10 young people working on it continuously in three shifts day and night. Nine times they worked on the calculation with the help of four hand-operated calculators. Even working so meticulously, they were not satisfied with the results, and they invited such specialists in theoretical physics as Zhou Guang to make their estimation based on physical conceptions. The results proved that Deng's scientific data was accurate and sound.

At 1500 on 16 October 1964, a fiery mushroom-shaped cloud rose with a boom in the sky above the vast Gobi Desert. This thunder which shocked the world proclaimed: The age when the Chinese people were bullied arbitrarily had come to an end!

Later, a reporter of Chinese origin living abroad wrote, saying: "When news of the successful trial explosion of China's first atomic bomb spread abroad, the ecstasy and pride of the Chinese people was beyond description. In the eyes of overseas Chinese, that mushroom-shaped explosion was the full bloom of the spiritual flower of the Chinese nation. And the news spread from the newspapers and radio broadcasts was the letter from home worth a thousand gold pieces."

The spiritual flower of the Chinese nation in full bloom was precisely cultivated by Professor Deng Jiaxian and thousands upon thousands of ordinary Chinese people; and the letter from home worth a thousand gold pieces was written in the skies with the sweat and blood of a large number of unknown heroes.

This Is the Battlefield, I Won't Leave!

Shortly after the successful explosion of the first atom bomb, when Deng Jiaxian's thrill had not been pacified, another job with still greater difficulties fell on his shoulders, as well as those of other scientists and technicians.

This was another job requiring arduous labor. As responsible person for organizing the theoretical design in the development of the H-bomb, the difficulties he met with were unimaginable. In winter 1965, the research and development of the H-bomb was at its critical juncture. Once in the still of the night the guard was still standing by the door of the computer workshop. People asked why he did not go to sleep, and he answered he was there "to stand guard for Lao Deng."

"I'm sure he is not going home tonight. We'll take care of him, and you had better go to bed." Deng spent the whole night in the workshop that night, and he did not leave the place until he got the results. Day in and day out, he never stopped for a moment in his work. Sometimes, he would just take a rest on the floor of the workshop. He was under constant stress, experiencing one success or failure after another and crucial moments of life and death together with his colleagues. Particularly after he was appointed director of the Nuclear Weaponry Research and Design Institute, he had always played an exemplary role, been bold at taking risks, and exerted all his efforts.

Nuclear weapon technology has always been an absolute top secret with the superpowers. It is impossible to get it through such channels as import and exchange, and it is unavailable no matter what amount of foreign currencies we have. Under the arduous and difficult conditions in China, the Chinese wanted to master these technologies with their own wisdom and

hands. Aside from necessary support from the party and state, Deng Jiaxian and the other scientists who participated directly in the research and development of the nuclear bombs, have paid a tremendous price beyond imagination for it.

"As an organizer and participant in the course of the research and development of the H-bomb and new strategic nuclear weapons, Deng is a man of great merit!" Deng's colleagues said in unison. Every important breakthrough in the development of new strategic nuclear weapons, and every successful milestone test is linked with Deng Jiaxian's name, they said. All year round, he was going from one place to another, going where the difficulties were, appearing at the posts where the work was most dangerous, in the workshops for special material processing, at the dynamic physical test ground, in the wilderness in snowstorms.

It was well after midnight one day and he had already gone to bed. The nuclear material processing workshop faraway suddenly called him on the phone; a problem had cropped up in the processing of a key part. He put down the phone, said nothing, and got into a car still in his slippers. At that time, he was close to 60. He drove the car at top speed on the rugged valley roads in complete darkness for more than 3 hours, and it was almost daybreak when he finally arrived at his destination. He did not take a moment's rest, and ran straight into the workshop which processed the nuclear material. A worker who persisted in his work despite his illness was greatly comforted when he saw the director on the site, who made light of all the hardships in getting there. Deng studied the problem together with the workers, and soon solved it.

As director and one who takes the lead among scientists and technicians, his every word and action in his personal appearances at critical moments was unforgettable and comforting to those under his leadership. Now, all the parts of the nuclear device had been prepared, and the general assembly work was to begin. The assembly hall was completely quiet, scientists and technicians would come in, each to his own assembly post. Deng Jiaxian held the hand of one of the technicians. "But, why is your hand so cold? Come, let me warm it for you," Deng said, and put his hand inside his coat. "There's no hurry; we have ample time!" The scientists and technicians understood his appearance at every critical moment, which needed no explanation: "Should anything happen, we'll die together!"

When they worked, the scientists and technicians always bore Deng's words in mind: "There must be a weight to make the balance work! Nothing is a trifle here. Everything is important here. Any small problem will bring a disaster if not properly solved." Therefore, he always repeatedly asked everybody: "Any more problems?" And he would not accept even the smallest hidden danger.

One day, in the workshop in which the nuclear device was to be stored at the test base, a technicians noticed a spark when positioning the crane which was to lift the nuclear device. It was already 5:00 in the morning and Deng had only gone to bed a little earlier because he had worked well

past midnight. Learning about the situation, he hurried to the site. But no matter how hard they tried in testing, the spark did not show again. He then decided to set up a specialized group to get to the bottom of the problem. When the technician saw that the director was serious and concerned about the problem, he became all the more energetic in his work, and got all the records concerned ready, examining every entry on who had been there, and what had been moved. The search for the cause did not end until past 1600 that afternoon when it was eventually pinned down.

Year in and year out, he led scientists and technicians in the bitter struggle of research and nuclear testing at the forefront, working selflessly, and spent a whole decade living alone without the company of his wife and children. The risks of failure, the joys of success, working in the open under attack from storms and frost, had turned his sideburns white, and his face was marked with deep wrinkles. However, a tremendous success almost cost him his life through over excitement.

This was during an underground nuclear test. Everything was ready, and all the people at the test ground were waiting for the solemn countdown to "zero." The nuclear device was slowly going down the shaft, and all testing devices were set to work, monitoring whether or not all kinds of scientific data were normal, but when the nuclear device was sent deep into the shaft, a signal on one of the testing devices failed to work.

"What are we to do?" The scientists and technicians returned to the tents, trying to find a way out. Some suggested taking the nuclear device from the shaft to make a thorough examination; others believed this to be too dangerous, and they were for continuing to send the device lower down the shaft when the problem was solved. Thus the discussion went on from midnight till dawn. Finally, having compared all suggestions, Deng decided to adopt appropriate measures on the site. Together with the scientists and technicians, Deng arrived in the neighborhood of the shaft, and studied a solution for the problem. The wind was howling over the Gobi Desert, and it was piercing cold, for the temperature was -30°C ! People found him exhausted, and said: "Director Deng, you had better go home!"

"No, here is the battlefield, I can't leave it!" Deng refused solemnly.

He did not leave the site until the trouble was ended. When the successful test was over, a celebration of the occasion was held, but he passed out after he drank just a small glass of wine in all his excitement, because he had not been eating regularly. Those at the scene laid him down hurriedly, and when his blood pressure was tested, it was shown to be very low.

"Director Deng! Director Deng...." People were calling his name, but he was still in a coma. He only opened his eyes after the doctors had applied first-aid throughout the night.

When he came to, the first thing he asked about was: What was the result of the nuclear explosion test? Was all the data ready? He just would not take a rest, and plunged into intense work.

Utter Loyalty to the Motherland

Of the 32 nuclear tests China has conducted, Deng Jiaxian has on 15 occasions been personally in charge of command in the test team headquarters. During this period, he was often on a tight schedule, going straight from the railway station to the airport. Sometimes, there was not even time for a normal meal, and he had to get some steamed bread from the canteen and start for the journey. Within the period of a month one year, he made two round trips from the factory to the test site, a distance of several thousand km! More often than not he would get straight to work the moment he stepped out of the plane. It was always between 3 and 4 hours sleep at night, and he would often work all night through. Sometimes, having just gone to bed, after a telephone call he would put on his clothes again and set out to work.

The tense work over long years impaired his health, but he totally ignored it. He passed out on the test ground on several occasions. Once, before a nuclear test was to take place in winter 1984, he started for the test ground, dragging his legs along with some difficulty on the snow-covered earth. Suddenly, he found himself unable to go on any longer, and said to the two scientists walking in front of him: "Give me a hand, please give me a hand!" So saying, he fell upon the shoulders of the two men breathlessly. It turned out that he had stomach trouble, and an attack of hypoglycemia. He was extremely weak, but he continued working after he had taken some candies and water.

When a breakthrough was made in H-bomb theory, he would be as happy as a child with every success of the nuclear test. At such moments, he would take cigarettes and candies from his pockets, and say with smiles: "I'll stand you a treat today!" And if circumstances permitted, he would invite everyone to dinner.

But Deng Jiaxian was always very strict on himself. People say, as a famous scientist and leading cadre, his daughter was the last to return to the urban areas from Nei Monggol, settling down there in the countryside. For years, whenever he returned to Beijing from the research and test base, he would always buy a bus ticket with money from his own pocket, and he would take the bus when he was out on business. Once, he went to visit his wife, who was then confined to a hospital. On his way home, he was caught in a shower without even an umbrella. When he got home from the bus stop, he was wet through. When asked why he had not taken the car specially provided for him, he said: "I am a communist, I shouldn't enjoy special privileges when dealing with my personal affairs."

Shortly before a nuclear test in late January 1984, Deng Jiaxian took several scientists and technicians along with him to report their work condition to Beijing. In another 2 days, he would have to fly back to the test site. At that time, the airplane fare happened to rise. When he learned that the difference in prices between front and back cabins would be 40 yuan, he told the others to book him a seat at the back cabin. He said: "Let's save as much as we can for the state!"

"Deng, with your academic level and experiences, it is entirely possible for you to make your life a bit more comfortable. You can travel at home and abroad and see the world, giving lectures and touring places. Why should you have selected such a path and willingly struggle on such an arduous post?" an engineer asked him when they were having a conference in Hangzhou.

"Yes, the West Lake is so beautiful! It seems that it's the first time that I have ever visited Hangzhou. I have never imagined that it could be so beautiful. It's surely a wonderful thing to see places. But, a person should always do more for the people!" he answered, viewing the fascinating West Lake scene.

When touring the tomb of Yue Fei, he purposely stood in front of the stone tablet with the inscription "Utter Loyalty to the Motherland," and said to his comrades: "Come, please take a picture of me here."

And that is Deng Jiaxian, a man who has dedicated his whole life to the motherland, a man who has written a new song of "Utter Loyalty to the Motherland" with his own life.

China's intellectuals are worthy of the pride of the Chinese nation. This is because thousands upon thousands of people like Deng Jiaxian are engaged in bitter struggle in oblivion, to rejuvenate the Chinese nation, seeking neither fame nor personal interests.

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CSO: 4008/83

GENERALIZED STEINER PROBLEM AND HEXAGONAL COORDINATE SYSTEM

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese
Vol 8, No 4, Oct 85 pp 383-397

[English abstract of article by Weng Jiafeng [5040 4471 0023] of Baoshan General Iron and Steel Works, Shanghai]

[Text] The Steiner Problem is to construct a graph, which covers a set of given points and has minimal length. If some given points are not fixed, but constrained in some regions, the correspondent problem is called Generalized Steiner Problem. In this paper we develop a new coordinate system--Hexagonal coordinate System, and hence obtain an analytical method for solving Steiner problem and its generalized form. (Paper received 17 Aug 81, finalized 17 May 84)

REFERENCES

- [1] E. J. Cockayne, On the Steiner Problem, *Can. Math. Bull.*, 10: 3(1967), 431-450.
- [2] E. N. Gilbert and H. O. Pollak, Steiner Minimal Trees, *SIAM J. Appl. Math.*, 16: 1(1968), 1-29.
- [3] S. K. Chang, The Generation of Minimal Trees with a Steiner Topology, *J. Assoc. Comput. Mach.*, 19: 4(1972), 699-711.
- [4] Z. A. Melzak, On the Problem of Steiner, *Can. Math. Bull.*, 4(1961), 143-148.
- [5] E. J. Cockayne, On the Efficiency of Algorithm for Steiner Minimal Trees, *SIAM J. Appl. Math.*, 18: 1(1970), 150-159.
- [6] M. R. Garey, R. L. Graham and D. S. Johnson, The Complexity of Computing Steiner Minimal Trees, *SIAM J. Appl. Math.*, 32: 4(1977), 835-859.
- [7] 翁稼丰, 正多边形顶点集上的斯坦纳最小树, 待发表.
- [8] R. Courant and H. Robbins, *What is Mathematics?*, Oxford Univ. Press, London, 1946.
- [9] 陈国先, 带(直线)约束时两点间最短连线, 数学的认识与实践, 4(1980), 1-8.

AN ENUMERATION FORMULA FOR SEQUENCES WITH A GIVEN NUMBER OF RUNS

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese
Vol 8, No 4, Oct 85 pp 460-466

[English abstract of article by Ke Xin [2688 2946] of Qinghua University]

[Text] Consider sequences with m_i 1's ($1 \leq i \leq k$). The theory of Mobius inversion is used to give a general solution formula for the sequences which have a certain number of runs. Specific formulas for some special cases are derived. (Paper received 17 Dec 83.)

REFERENCES

- [1] 张忠辅, 蔡茂诚, 林谔勋, 关于连贯的计数问题, 应用数学学报, 5:3(1982), 285-290.
- [2] 钟秉, 有给定连贯数的序列的计数问题, 华南师院学报(自然科学版), 2(1982), 1-8
- [3] 屠炳彰, 组合计数方法及其应用, 科学出版社, 北京, 1981 年.
- [4] 徐利治, 蔡茂森, 朱自强, 计算组合数学, 上海科学技术出版社, 1983 年.

THE VARIATIONAL PROBLEM FOR THE BOUSSINESQ EQUATION AND RELATED BACKLUND TRANSFORMATION AND SOLITON SOLUTION

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese
Vol 8, No 4, Oct 85 pp 482-488

[English abstract of article by Cheng Ansheng [2052 1344 3932] of Shanghai Institute of Computing Technology]

[Text] A Backlund transformation for the Boussinesq equation is obtained. We consider the divergence due to the Lagrangian and the condition of the simple Backlund transformation, thus deriving a number of relations with many parameters that may be restricted to certain values. For example, taking some suitable values, we can produce a Backlund transformation which accords with the result given in [3]. Similarly, given corresponding conditions, the soliton solution made in [3] will be a special case of our result. (Paper received 22 Dec 83.)

REFERENCES

- [1] Hanno Rund. Variational problems and Backlund transformations associated with the Sine-Gordon and Korteweg-Devries equations and their extensions. Backlund transformation. (R. M. Miura. ed) Springer-Verlag, 1974. 194—226.
- [2] Hsing-Hen Chen. Relation between Backlund transformations and inverse scattering problems. Backlund transformations. (R. M. Miura. ed) Springer-Verlag, 1974, 241—252.
- [3] 屠炳彰, Boussinesq 方程的 Backlund 变换与守恒律. 应用数学学报, 4: 1(1981), 63—68
- [4] George, M. Murphy. Ordinary differential equations and their solutions. D. van Nostrand Company (Canada), LTD. 1960.

THE SPACE H^2 OF ANALYTIC FUNCTION VECTORS

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese
Vol 8, No 4, Oct 85 pp 498-504

[English abstract of article by Ni Zhongren [0242 1813 0088] of Beijing University]

[Text] Beurling described in 1949 all the invariant subspaces for the operator "multiplication by z " on the Hilbert space H^2 of analytic functions in the unit disc. Let H^2 be the space composed of analytic functions of class H^2 in the unit disc, S be a non-trivial closed subspace of H^2 , and z be a complex variable. Beurling obtained the following conclusions:

- (1) $zS \subset S$ if and only if S has the form $S=F(z)H^2$, where $F(z)$ is an inner function;
- (2) when $S=F(z)H^2$, $F(z)$ is the greatest common divisor of the inner parts of the functions in S ;
- (3) let $h(z)$ be a function in H^2 . Then $z^n h(z)$, $n=0, 1, 2, \dots$ span H^2 if and only if $h(z)$ is an outer function.

In this paper, Beurling's conclusions have been expanded to the spaces of analytic function vectors. (Paper received 29 Mar 84.)

REFERENCES

- [1] K. Hoffman, Banach spaces of analytic functions, 1962.
- [2] И. П. 那汤松著, 徐瑞云译, 实变函数论(下册), 人民教育出版社, 北京, 1958年12月.
- [3] И. И. 普里瓦洛夫著, 吴泰仁译, 解析函数的边界性质, 科学出版社, 北京, 1956年.
- [4] Ю. А. Розанов, Спектральные свойства многомерных процессов и граничные свойства аналитических матриц, Теор. Вероят. и её примен. V, 4 (1960), 399-414.
- [5] Г. Н. 哈代, W. W. 洛戈辛斯基著, 徐瑞云、王斯雷译, 富里哀级数, 上海科技出版社, 1978.
- [6] В. И. Крылов, О функциях, регулярных в полуплоскости, Матем. сб., 6 (48) (1939), 95-138.

METHODS OF CALCULATING HOE AND THE TEST RESULTS

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 1,
Jan 86 pp 100-106

[English abstract of article by Wang Yongshao [3769 3057 2507], et al., of
Department of Precision Instruments Tianjin University Tianjin, China]

[Text] This paper presents two methods of calculating HOE between the spherical wavefronts, and elliptical Gaussian and spherical wavefront. The test results obtained in computer-generated holograms are given, too. (Paper received 19 Oct 84.)

REFERENCES

- [1] A.W. Lohmann, D.P. Paris, Appl. Opt. 6,1739(1967).
- [2] J. Pastor, Appl. Opt. 8, 525(1969).
- [3] C.S.Ih, Appl. Opt. 17,748(1978).
- [4] C.S.Ih,王永刚 "Computer generated HOE for injection Laser",1982
Annual meeting of the Optical Society of America.

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CSO: 4009/1057

THEORY AND APPLICATIONS OF RANDOM OPERATORS IN PROBABILISTIC METRIC SPACES

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese
Vol 9, No 2, Apr 86 pp 129-137

[English abstract of article by Zhang Shisheng [1728 4258 3932] of Sichuan University]

[Text] The theory of random operators on a special class of probabilistic metric space, E-space, is considered. As an application, we utilize the results obtained to study the existence and uniqueness of random solutions of nonlinear random operator equations and of the system of nonlinear random operator equations. (Paper received 13 Apr 83.)

REFERENCES

- [1] 游兆永, 概率度量空间压缩映象的拟 Picard 迭代收敛性定理, 数学研究与评论, 创刊号(1981), 25—28.
- [2] 王粹坤, 随机泛函分析引论, 数学进展, 5: 1(1962), 45—71.
- [3] 林 熙, 一类概率赋范线性空间与随机算子, 科学通报, 4(1983), 199—201.
- [4] V. M. Sehgal, A. T. Bharucha-Reid, Fixed Points of Contraction Mappings on Probabilistic Metric Spaces, *Math. Systems Theory*, 6; 2(1972), 97—102.
- [5] C. A. Drossos, Stochastic Menger Spaces and Convergence in Probability, *Revue Roumaine Math. Pures et Appl.*, Tome 22; 8(1977), 1069—1076.
- [6] K. Menger, Statistical Metrics, *Proc. Nat. Acad. Sci. USA*, 28(1942), 535—537.
- [7] B. Schweizer, A. Sklar, Statistical metric spaces, *Pacific J. Math.*, 10(1960), 313—334.
- [8] H. Sherwood, On E-Spaces and Their Relation to Other Classes of Probabilistic Metric Spaces, *J. London Math. Soc.*, 44(1969), 441—448.
- [9] H. Sherwood, On the Completion of Probabilistic Metric Space, *Z. Wahrscheinlichkeitstheorie Verw. Gebiete*, 6(1966), 62—64.
- [10] A. N. Serstnev, The notion of random normed space, *Dokl. Acad. Nauk, U. S. S. R.*, 149(2) (1963), 280—283.
- [11] Gh. Bocsan, On some fixed point theorems in random normed spaces, *Proc. 5th Conf. On Probability Theory* (1974), 153—155.

A FAST ALGORITHM OF POLYNOMIAL REGRESSION

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese Vol 9, No 2, Apr 86 pp 146-153

[English abstract of article by Huang Junqin [7806 0193 2953] and Liu Zhengshe [0491 2419 4357] of Beijing Institute of Aeronautics and Astronautics]

[Text] A fast algorithm of polynomial regression is established as a result of improving the Householder's solution for overdetermined equations while keeping its high-accuracy characteristics. The algorithm can determine the order of a polynomial model and give the least squares estimate of the model parameters. If the order of the model is n the computational time is only equal to that of the solution of an n th order overdetermined equation, much less than the existing methods. (Paper received 12 Sep 83.)

REFERENCES

- [1] 南京大学数学系计算数学专业, 概率统计基础和概率统计方法, 科学出版社, 北京, 1979, 228-233.
- [2] S. Haykin, Nonlinear Methods of Spectral Analysis, Springer-Verlag Berlin Heidelberg, New York, 1979, 41-48.
- [3] 黄俊钦、张继志, 一种同时辨识模型阶次和参数的方法, 仪器仪表学报, 5: 4(1984), 339-345.
- [4] 黄俊钦, 测试误差分析与数学模型, 国防工业出版社, 北京, 1985, 195-208.
- [5] 冯康等, 数值计算方法, 国防工业出版社, 北京, 1978, 255-259.
- [6] AD755533.

FAMILIES OF POINT-TO-SET MAPS AND OPTIMIZATION ALGORITHMS

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese Vol 9, No 2, Apr 86 pp 165-177

[English abstract of article by Chen Guangjun [7115 1639 6511] of Qufu Teachers' College]

[Text] Some general algorithms were constructed for optimization by families of point-to-set maps, some of which were improvements of the algorithms introduced in [2] and [3]. We showed that under weakened hypotheses the algorithms had better convergence properties. If there was only one member in the family of point-to-set maps, some extensions of Zangwill's theorem were special cases of the algorithms. As an example, the convergences of the variable metric algorithm and Cauchy steepest ascent algorithm with inexact line search were given. (Paper received 28 Nov 83.)

REFERENCES

- [1] Zangwill, W. I., *Nonlinear Programming, A Unified Approach*, (Prentice Hall, Englewood Cliff, RI), 1969.
- [2] Denel, J., Extensions of the Continuity of Point-to-Set Maps: Applications to Fixed Point Algorithms, *Mathematical Programming Study*, 10(1979), 48-68.
- [3] Yue Minyi, On a ρ -increasing family of Point-to-Set Maps, *Chin. Ann. of Math.*, 3: 4(1982), 403-414.
- [4] Huard, P., Extensions of Zangwill's Theorem, *Mathematical Programming Study*, 10(1979), 98-103.
- [5] 堵丁柱, 点到集映像和点到集映像族的连锁化, *应用数学学报*, 8: 2(1985), 142-150.

THE DURBONX TRANSFORMATION OF AN EIGENVALUE PROBLEM AND THE SOLITON SOLUTIONS
OF THE SINE-GORDON EQUATION WITH EXTERNAL FIELD

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in
Chinese Vol 9, No 2, Apr 86 pp 196-200

[English abstract of article by Li Yishen [2621 5042 4377] of University of
Science and Technology of China]

[Text] The Darboux transformation's method is used to give the solutions
of the sine-Gordon equation with external field. (Paper received 16 May 84,
finalized 3 Dec 84.)

REFERENCES

- [1] G. L. Lamb, Elements of Soliton Theory, Wiley, New York, 1980.
- [2] L. D. Faddeev, The Inverse Problem in the Quantum Theory of Scattering, *Uspekhi Mat. Nauk.* 14(1959), 57.
- [3] M. Wadati, H. Sannki, K. Konno, Relationships Among Inverse Method Bäcklund Transformation and Infinite Number of Conservation Laws, *Prog. Theor. Phys.*, 53 (1975), 419.
- [4] P. Deift, E. Trubovitz, Inverse Scattering on the Line *Comm. Pure and Appl. Math.* 32 (1974), 121.
- [5] D. Levi, O. Ragnisco, A. Sym, Dressing Method Vs Classical Darboux Transformation. Preprint, 1983.
- [6] G. Nevgebauer, R. Meinel, "General N-Soliton on the AKNS Class on arbitrary Background, *Phys. Lett. A* 100 (1984), 467.
- [7] 陈登远, AKNS 系统的贝克隆变换可交换性与叠加公式, 讨论班报告, 1984.
- [8] 李明神, Kaup Newell 特征值问题的达布变换, 讨论班报告, 1984.
- [9] M. Boiti, G. Z. Tu, A Simple Approach to the Hamilton Structure of Soliton Equation III, *Nuovo Limento*, 75B (1983), 145.

CHAOTIC BEHAVIOR OF HAMILTON SYSTEM WITH TWO DEGREES OF FREEDOM

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese Vol 9, No 2, Apr 86 pp 210-214

[English abstract of article by Liu Zengrong [0491 2582 2837] of Anhui University; and Li Jibin [2621 4949 1755] of Kunming Engineering Institute]

[Text] Hamilton systems having two degrees of freedom with quadratic and cubic nonlinearities, which exist widely in the field of nonlinear oscillation were discussed. By use of the Melnikov method, we find the conditions that result in chaos in the systems. It is illustrated that the chaotic phenomenon is an extremely universal nonlinear phenomenon in the free oscillation system with multi-degrees of freedom. (Paper received 28 May 84, finalized 29 Oct 84.)

REFERENCES

- [1] 薛柏林, 分叉, 混沌, 奇怪吸引子, 湍流和其他, 物理学进展, 3(1983), 329—416.
- [2] 朱照宣, 非线性动力学中的混沌现象, 力学进展, 14(1984), 129—146.
- [3] Edward. Ott, Strange Attractors and Chaotic Motions of Dynamical Systems, *Review of Modern Physics*, 53(1981), 635—671.
- [4] J. Guckenheimer and P. Holmes, Nonlinear Oscillation, Dynamical Systems and Bifurcations of Vector Fields, Springer-Verlag, 1983.
- [5] 李健彬, 刘曾荣, 一类二次系统周期扰动的混沌性质, 科学通报, 30: 7(1985), 491—495.
- [6] Holmes, P. J. and Marsden, J. E., Horseshoes in Perturbation of Hamiltonian with two Degree of Freedom, *Comm. Math. Phys.*, 82 (1982), 523—544.

EXACT NULL CONTROLLABILITY FOR A CLASS OF DISCRETE INFINITE DIMENSIONAL LINEAR SYSTEM WITH CONTROL ENERGY CONSTRAINT

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese Vol 9, No 2, Apr 86 pp 222-226

[English abstract of article by Chen Zhaokuan [7115 0340 1401] of Shandong University]

[Text] A problem of exact null controllability for a class of discrete infinite dimensional linear system with control energy constraint is discussed. A necessary and sufficient condition for this controllability is obtained with using the method of the eigenvector development of the linear operator. (Paper received 5 Jun 84, finalized 19 Aug 85.)

REFERENCES

- [1] 陈云等、赵怡,线性系统的能控区及其在最优控制中的某些应用,中山大学学报,4(1980),29-38.

ADMISSIBILITY OF LINEAR ESTIMATORS OF REGRESSION COEFFICIENT IN A GENERAL GAUSS-MARKOFF MODEL

Beijing YINGYONG SHUXUE XUEBAO [ACTA MATHEMATICAE APPLICATAE SINICA] in Chinese Vol 9, No 2, Apr 86 pp 251-256

[English abstract of article by Wu Qiguang [0702 0796 0342] of Institute of Systems Science, Academia Sinica]

[Text] Let Y be a random n -vector with mean $X\beta$ and covariance matrix $\sigma^2 V$, where X is a known $n \times p$ matrix and V is a known symmetric nonnegative definite matrix; $\beta \in \mathbb{R}^p$ and $\sigma^2 > 0$ are parameters. Let $S\beta$ be linearly estimable. The necessary and sufficient conditions for a linear estimator of $S\beta$ to be admissible among linear estimators under the quadratic loss function and matrix loss function are obtained respectively. (Paper received 11 Jul 84.)

REFERENCES

- [1] C. R. Rao, Estimation of parameters in a linear model, *Ann. Statist.*, 4(1976), 1023-1037.
- [2] Wu Qiguang, Admissibility of linear estimates of regression coefficient under matrix loss function, *Kexue Tongbao*, 28(1983), 155-158.
- [3] 朱昱海, 关于可容许估计的两个定理 (内部资料).

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Chemistry

STUDY OF SPECTRA AND CRYSTAL STRUCTURE OF BIPYRIDINE BRIDGING Cu(II) ACETYLACETONATE COMPLEX [μ -4,4-bipy-Cu(acac) $_2$]

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 44, No 4, Apr 86
pp 336-342

[English abstract of article by Xu Yuanzhi [1776 0337 2784] and Shi Shu [2457 5289] of Department of Chemistry, Zhejiang University, Hangzhou]

[Text] The crystal and electronic structures of bipyridine bridging Cu(II) acetylacetonate complex [μ -4, 4-bipy-Cu(acac) $_2$] have been studied. The crystals belong to monoclinic system, and space group is $P2_1/n$. Its unit cell parameters are: $a=11.288(5)$, $b=14.507(6)$, $c=11.978(3)\text{\AA}$; $\beta=94.17^\circ$ and $V=1956(2)\text{\AA}^3$, $Z=4$, $D_m=1.39\text{ g/cm}^3$, $D_c=;/42\text{ g/cm}^3$. Final unweighted factor $R=0.054$ for 2260 independent reflections. It is confirmed that the Cu(acac) $_2$ and 4,4-bipy form a one-dimension infinite linear structure with molecular ratio 1:1. By using UV, IR, ESR and NMR spectra, the bonding characteristics of [μ -4, 4-bipy-Cu(acac) $_2$] were compared to Cu(acac) $_2$. From ESR spectral parameters, the coefficients of molecular orbitals α_1 , α_1' and ϵ_π are calculated approximately. The existence and relative magnitude of contact shifts, pseudo-contact shifts and anisotropic shielding effects are given by analysis of ^1H NMR spectrum. (Paper received 15 Oct 84, finalized 17 Apr 85.)

REFERENCES

- [1] Cotton, F. A.; Wilkinson, G., "Advanced Inorganic Chemistry", 3rd Edn., Wiley, New York, 1972, p. 492.
- [2] Graves, J.; Dias, R. M., "The Coordinative Chemistry of Metalloenzymes", Baile, D. Co., 1983, p. 79.
- [3] Karlin, K. D.; Dahlstrom, P. L.; Dipierro, L. J.; Simon, R. A.; Zubieta, J., *J. Coord. Chem.*, 1981, 11, 61.
- [4] Phipps, D. A., "金属与代谢", 科学出版社, 北京, 1983, p. 169.
- [5] Fenton, D. E.; Linstead, B. L., *J. Am. Chem. Soc.*, 1972, 100, 6367.
- [6] Tomlinson, A. A. G.; Hathaway, B. J.; Billing, D. E.; Nichol, P., *J. Chem. Soc. (A)*, 1969, 65.
- [7] Procter, I. M.; Stephens, F. S., *J. Chem. Soc. (A)*, 1969, 1248.
- [8] Crapanzana, S. A.; Illiyaw, E. A., *J. compyn. sumus.*, 1969, 10, 290.
- [9] Hathaway, B. J.; Billing, D. E., *Coord. Chem. Rev.*, 1970, 5, 143.
- [10] Kivelson, D.; Lee, S. K., *J. Chem. Phys.*, 1964, 41, 1896.
- [11] Eaton, D. R., *J. Am. Chem. Soc.*, 1965, 87, 8097.
- [12] 徐元植, 施舒, 待发表.
- [13] Happe, J. A.; Ward, R. L., *J. Chem. Phys.*, 1963, 39, 1211.
- [14] McConnell, H. M.; Chesnut, D. B., *J. Chem. Phys.*, 1956, 25, 107.
- [15] 唐放庆, 江元生, 耶国森, 戴树珊, "分子轨道图形理论", 科学出版社, 北京 1980, p. 20.

INVESTIGATION OF SINGLE MoFe_3S_4 CUBANE CLUSTER

I. SYNTHESIS BY SPONTANEOUS SELF-ASSEMBLY REACTION AND STRUCTURE OF $(\text{Et}_4\text{N}) [\text{MoFe}_3\text{S}_4(\text{Et}_2\text{NCSS})_5]\text{CH}_3\text{CN}$

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 44, No 4, Apr 86 pp 343-349

[English abstract of article by Liu Qiutian [0491 4428 3944], et al., of Fujian Institute of Research on the Structure of Matter, Academia Sinica, Fuzhou]

[Text] A single MoFe_3S_4 cubane-like cluster compound has been synthesized through spontaneous self-assembly of simple inorganic salts with organosulfur ligand for the first time. $(\text{Et}_4\text{N}) [\text{MoFe}_3\text{S}_4(\text{Et}_2\text{NCSS})_5]\text{CH}_3\text{CN}$ (1) is quite stable in air. The crystal of 1 is monoclinic with space group $\text{P}2_1/\text{c}$, $a=22.897(3)\text{\AA}$, $c=20.928(4)\text{\AA}$, $\beta=97.15(1)^\circ$ and $Z=4$. A full matrix least-squares refinement with 6725 unique reflections for all nonhydrogen atoms gives $R=0.068$.

The anion of 1 is the first isolated single MoFe_3S_4 cubane cluster with core oxidation state $[\text{MoFe}_3\text{S}_4]^{4+}$. The distance between the two six-coordinate metal atoms (Mo, Fe) is $2.624\text{\AA}$, which is the shortest M-M bond observed for Mo-Fe-S clusters so far and the only one shorter than similar distances in FeMo-cofactor.

The bond orders for this anion were calculated by EHMO method and the results coincide with the general rule. The structural feature and the unusual stability of 1 can be attributed to the bidentate chelating effect of Et_2NCSS , which leads to high coordination of metal atoms and the various ligated types. (Paper received 8 Jan 85.)

REFERENCES

- [1] (a) 中国科学院福建物质结构研究所固氮研究小组, 科学通报, 1975, 20, 540; (b) Lu J.-X., "Nitrogen Fixation", Vol. I, ed. by Newton, W. E.; Orme-Johnson, H. E., University Park Press, Baltimore, 1980, p. 343.
- [2] Cramer, S. P.; Hodgson, K. O.; Gillum, W. O.; Mortenson, L. E., *J. Am. Chem. Soc.*, 1978, 100, 3398.
- [3] Holm, R. H., *Chem. Soc. Rev.*, 1981, 10, 455.
- [4] Christou, G.; Garner, C. D.; Mabbs, F. E.; King, T. J., *J. Chem. Soc. Chem. Commun.*, 1978, 740.
- [5] (a) Mascharak, P. K.; Armstrong, W. H.; Mizobe, Y.; Holm, R. H., *J. Am. Chem. Soc.*, 1983, 105, 475; (b) Palermo, R. E.; Holm, R. H., *J. Am. Chem. Soc.*, 1983, 105, 4310; (c) Palermo, R. E.; Singh, R.; Bashkin, J. K.; Holm, R. H., *J. Am. Chem. Soc.*, 1984, 106, 2600.
- [6] 刘秋田, 黄梁仁, 王玲玲, 康北笙, 卢嘉锡, 结构化学, 1983, 2, 291.
- [7] Burgess, B. K.; Yang, S. S.; You, C. B.; Li, J. G.; Friesen, G. D.; Pan, W. H.; Stiefel, E. I.; Newton, W. E.; Conradson, S. D.; Hodgson, K. O., "Current Perspectives in Nitrogen Fixation", ed. by Gibson, A. H.; Newton, W. E., Australian Academy of Science, Canberra, 1981, p. 71.
- [8] Katsuzidis, M. G.; Ryan, M.; Coucouvanis, D., *Inorg. Chem.*, 1983, 22, 179.

THE KINETIC STUDY FOR SELECTIVE OXIDATION OF PROPYLENE ON THE CATALYSTS OF BISMUTH AND CERIUM MOLYBDATE MIXTURES

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 44, No 4, Apr 86 pp 350-356

[English abstract of article by Yang Huixing [2799 1920 2502], et al., of Department of Chemistry, Peking University, Beijing]

[Text] The influence of Ce on the selective oxidation of propylene catalyzed by bismuth molybdate was studied. Kinetic results show that different Bi-Ce ratios of the catalyst exhibit comparatively complex behaviors. Following the change of the composition of the catalyst, the order of the oxidation changes from zero through 0.5 to no definite order and simultaneously the order for propylene also undergoes a great change as the composition of catalyst changes. To explain this phenomenon, an unified reaction mechanism is suggested so that as the composition of the catalyst changes the surface active center changes from the lattice oxygen, through the atomic state, to molecular state. Through X-ray, infrared and other studies, it is shown that, such a change of surface active centers is due to the formation of cerium molybdate phase which spoiled the formation of lattice of bismuth molybdate, thus making the latter more dispersed. (Paper received 11 Jan 85.)

REFERENCES

- [1] Keulks, G. W.; Krenzke, L. D.; Notermann, T. N., *Adv. Catal.*, **1978**, *27*, 183.
- [2] Krenzke, L. D.; Keulks, G. W., *J. Catal.*, **1980**, *61*, 316.
- [3] Monnier, J. R.; Keulks, G. W., *J. Catal.*, **1981**, *68*, 51.
- [4] Monnier, J. R.; Keulks, G. W., *J. Catal.*, **1981**, *68*, 63.
- [5] 张要奇, 未发表.

SYNTHESIS OF 1,1,1-TRICHLORO-2-SUBSTITUTED HYDRAZINO-3-NITROPROPANE AND ITS DERIVATIVES

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 44, No 4, Apr 86 pp 360-373

[English abstract of article by Chen Qijie [7115 0366 2638] of Institute of Element-Organic Chemistry, Nankai University, Tianjin]

[Text] The syntheses of forty-three novel aliphatic and aromatic hydrazine, hydrazide, azo and hydrazone compounds from 1,1,1-trichloro-2-acetoxy-3-nitropropane and 1,1,1-trichloro-2-hydrazino-3-nitropropane were described.

Alkyl β -nitropyruvate arylhydrazone can be obtained conveniently by oxidation of N-aryl -N'-[2-(1,1,1-trichloro-3-nitro)propyl] hydrazine with N-bromosuccinimide followed by the treatment with excess alcohol and equivalent amount of water without isolating the intermediary 1,1-dichloro-2-arylaazo-3-nitropropane. This is a simple and convenient method for the preparation of β -substituted pyruvate derivatives in relatively high yields.

Preliminary bioassays indicated that most of these compounds exhibited various degree of fungistatic activity. The hydrazine and azo derivatives are more effective than the pyruvate hydrazones. (Paper received 25 Jun 84, finalized 28 Dec 84.)

REFERENCES

- [1] 陈其杰, 刘凤祥, 谢之顺, 张玉芬, 张祖新, 卢建华, 农药, 1983, (3), 3.
- [2] Royals, E. E., "Advances Organic Chemistry", Prentice-Hall Inc., New York, 1964, p. 653.
- [3] Chattaway, F. D.; Witherington, P., J. Chem. Soc., 1939, 1179.
- [4] Brower, F. D.; Burkett, H., J. Am. Chem. Soc., 1953, 75, 1082.
- [5] Tomita, M.; Ikawa, K., J. Pharm. Soc. Jpn., 1955, 75, 449.
- [6] Friedman, L.; Little, B.; Reichle, W. B., "Organic Syntheses", Coll. Vol. V, ed. by Baumgarten, H. B., 1973, p. 1055.
- [7] Kulka, M., Can. J. Chem., 1959, 37, 525.
- [8] Bechman, G. B.; Standish, N. W., J. Org. Chem., 1961, 26, 1474.
- [9] Hadzi, D.; Jan, J., Rev. Roumaine Chim., 1965, 10, 1183 [Chem. Abstr., 1966, 65, 600e].
- [10] Bellamy, L. J., "The Infra-red Spectra of Complex Molecules", Chapman & Hall, London, 1973, pp. 204, 207, 209.
- [11] Chamberlain, N. F., "The Practice of NMR Spectroscopy with Spectra-Structure Correlations for Hydrogen-1", Plenum Press, New York 1974, pp. 183, 189.
- [12] Kitaev, Yu. P.; Nivorosshkin, L. E.; Titova, Z. S.; Popova, G. V., Izv. Akad. Nauk SSSR, Ser. Khim., 1968, 739 [Chem. Abstr., 1968, 69, 76456y].
- [13] Breitmaier, E.; Voelter, W., "13C NMR Spectroscopy", 2nd Edn., Verlag Chemie, Weinheim, New York, 1978, pp. 78, 174, 181.
- [14] Chattaway, F. D.; Daldy, F. G., J. Chem. Soc., 1938, 2756.
- [15] Crane, C. W.; Forrest, J.; Stephenson, O.; Waters, W. A., J. Chem. Soc., 1946, 839.

CRYSTAL STRUCTURE OF EUROPIUM TRICHLORIDE TETRAPYRIDINE

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 44, No 4, Apr 86
pp 388-391

[English abstract of article by Hu Ninghai [5170 1337 3189], et al., of Changchun Institute of Applied Chemistry, Academia Sinica, Changchun]

[Text] The crystal of europium trichloride tetrapyridine ($\text{EuCl}_3 \cdot 4\text{PY}$) belong to the monoclinic system. The space group is $P2_1/n$, with $a=15.925(4)$, $b=17.225(5)$, $c=9.780(7)\text{\AA}$, $\beta=103.28(2)^\circ$, $Z=4$. The intensity data of 5045 independent reflections were collected using a PW-1100 four-circle diffractometer. The structure was solved by the heavy-atom method. The structure parameters were refined by block-diagonal least-squares method, final discrepancy $R=0.073$. A slightly distorted pentagonal bipyramid polyhedron is formed by three chlorine and four nitrogen atoms surrounding the europium atom. The average bond lengths: $\text{Eu}-\text{Cl}=2.654\text{\AA}$ and $\text{Eu}-\text{N}=2.600\text{\AA}$. (Paper received 17 Dec 84.)

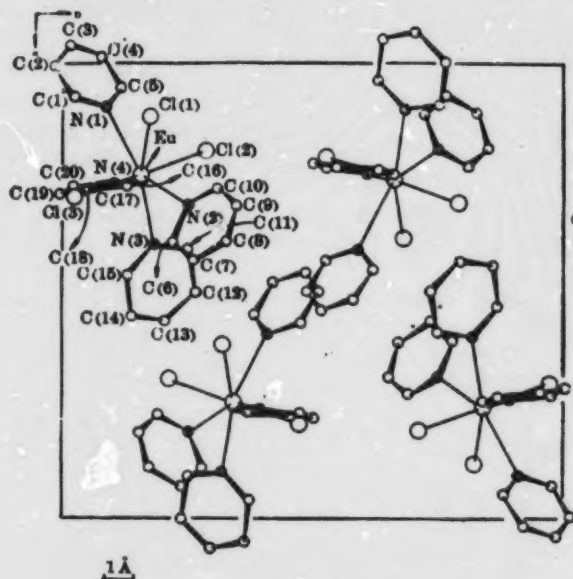


Fig. 1. Shadowing of crystal structure at (001) plane

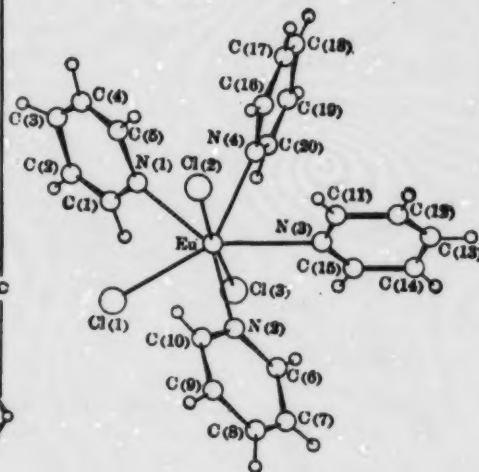


Fig. 2. Structural type of $\text{EuCl}_3 \cdot 4\text{Py}$ molecule

REFERENCES

- [1] Matignon, C., *Ann. Chem. Phys.*, **1908**, *8*, 243.
- [2] 沈琪, 张志敏, 田鹤琴, 张淑芬, 刘国智, *应用化学*, **1984**, *2*, 95.
- [3] 中国科学院长春应用化学研究所, "稀土化学论文集", 科学出版社, 北京, **1983**, 123.
- [4] Al-Karaghoul, A. B.; Wood, J. S., *J. Am. Chem. Soc.*, **1968**, *90*, 6548.
- [5] Horrocks, W. D., Jr.; Sipe, J. P., III; Luber, J. R., *J. Am. Chem. Soc.*, **1971**, *93*, 5258.
- [6] Morosin, B., *J. Chem. Phys.*, **1968**, *49*, 3007.
- [7] 汤卡罗, 甘宏, 潘佐华, 金祥林, *北京大学学报(自然科学版)*, **1984**, *3*, 43.

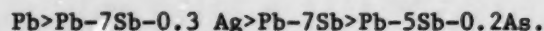
THE ANODIC FILM OF LEAD-ANTIMONY ALLOYS IN SULFURIC ACID SOLUTION

III. THE EFFECT OF CYCLIC TRIANGULAR WAVE POTENTIAL SWEEP ON THE GROWTH OF THE ANODIC FILM

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 44, No 4, Apr 86 pp 399-401

[English abstract of article by Zhou Weifang [0719 0251 5302], et al., of Department of Chemistry, Fudan University, Shanghai]

[Text] The anodic film on lead and three kinds of its Sb-based alloys in $4.5 \text{ mol} \cdot \text{dm}^{-3} \text{ H}_2\text{SO}_4$ (30°C) are studied by cyclic voltammetry with sweep rate of $9.2 \text{ mV} \cdot \text{s}^{-1}$, and sweep potential range between 0.90 and 1.45V vs. Hg/Hg₂SO₄ electrode. Cyclic voltammetry shows the major constituent of the said anodic film formed during a 50 cycle test is porous PbO₂ film. The order of decreasing growth rate of PbO₂ film is:



(Paper received 21 Jan 85.)

REFERENCES

- [1] Zhou Weifang, Chen Xialin [7115 7209 3781] HUAXUE XUEBAO [ACTA CHIMICA SINICA] Vol 43, 1985 p 333.
- [2] Zhou Weifang, Chen Xialin, HUAXUE XUEBAO [ACTA CHIMICA SINICA] Vol 43, 1985 p 810.

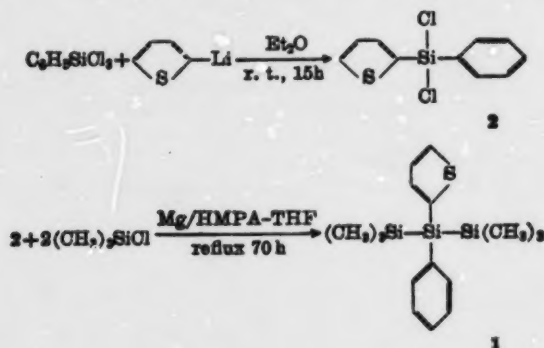
III. THE GENERATION AND TRAPPING OF α -THIENYLPHENYLSILYLENE

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 44, No 4, Apr 86 pp 427-430

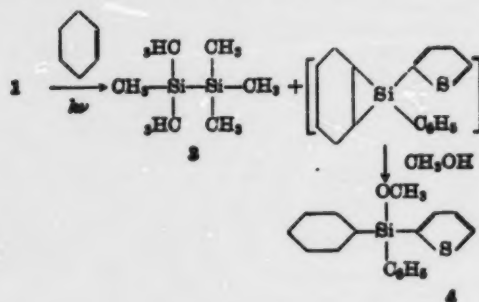
[English abstract of article by Wu Shihui [0702 0013 2547], et al., of Department of Chemistry, Fudan University, Shanghai]

[Text] Both carbenes (Divalent carbon) and its counterparts silylenes (divalent silicon) are elementary intermediates. But up to now, there is only one paper talked about hetrocycle containing silylene. In that paper we have reported the generation and trapping of furylphenylsilylene. The thiophene ring contains a sulfur atom, which locates at the same group with the oxygen of furan. But the sulfur belongs to third-row element, its out-shell electrons are 3s and 3p. Those electrons are farther away from the nucleus. So it might have some properties differing from that in furylphenylsilylene.

The precursor for the generation of α -thienylphenylsilylene is 2-(α -thienyl)-2-phenylhexamethyltrisilane (1). When α -thienyllithium reacted with phenyltrichlorosilane, α -thienylphenyldichlorosilane (2) was obtained (yield 32.9%). 2 and trimethylchlorosilane in the presence of hexamethylphosphoramide (HMPA) in tetrahydrofuran reacted with magnesium, and then compound 1 to be produced (yield 32%).



Irradiation of 1 in cyclohexene and methanol by a 450W Honovia lamp for 12 h, two expected products were obtained: hexamethyldisilane (yield 23.9%) and α -thienylphenylcyclohexylmethoxysilane (4) (yield 9.3%).



The structure of **4** was confirmed by conventional synthesis of authentic compound and compared their spectroscopy data. When **2** reacted with cyclohexylmagnesium bromide and treated with methanol, the authentic sample of **4** was obtained.

It is clear that we have trapped the first thiophene containing silylene.

The analytical data of compound **1** and **4** are following:

1 $C_{16}H_{20}Si_2S$ (calculated: C, 57.42; H, 7.83. Found: C, 57.62; H, 7.86). λ_{max} (EtOH): 260nm. ν_{max} : 3050(m, —OH), 2950(s, CH_3), 2900(m, CH_2), 1585(vw) and 1480(w) (benzene ring and thiophene ring), 1425(m, SiC_6H_5), 1400(m, $SiCH_3$), 1245(s, $SiCH_3$), 1210(m, substituted thiophene ring), 1092(s, SiC_6H_5) cm^{-1} . δ_H (CCl_4 , CH_2Cl_2 as inner standard): 0.29[18 H, s, $6 \times (SiCH_3)$], 7.17~7.66(8 H, m, Ar—H and thienyl protons) ppm. m/z : 334(M^+ , 16.62%), 73[(CH_3) $_2Si^+$, 100].

4 $C_{17}H_{22}OSiS$ (calculated: C, 67.50; H, 7.33. Found: C, 67.43; H, 7.30). ν_{max} : 3060(w, —OH), 2985(s, CH_3), 2920(m, CH_2), 1588(vw) and 1492(w, benzene ring and thiophene ring), 1425(m, SiC_6H_5), 1400(m, $SiCH_3$), 1210(m, substituted thiophene ring), 1110(s, $SiOCH_3$), 1085(s, SiC_6H_5) cm^{-1} . δ_H (CCl_4 , CH_2Cl_2 as inner standard): 1.19~2.18 (11 H, m, cyclohexyl protons), 3.60(3 H, s, OCH_3), 7.15~7.69 (8 H, m, Ar—H and thienyl protons) ppm. m/z : 302(M^+ , 5.72%), 219($M^+ - C_6H_{11}$, 100).

(Paper received 25 Sep 85.)

REFERENCES

- [1] (a) Gaspar, P. P., "Reactive Intermediates", ed. by Moss, R. A.; Jones, M., Jr., Wiley, New York, 1973; Vol. 1, Chap. 3, p. 69; (b) Idem, Ibid., 1981; Vol. 2, Chap. 3, p. 59; (c) 陶凤岗, 许临晓, 吴世群, 有机化学, 1983 (3), 161; (d) Gaspar, P. P., "Reactive Intermediates", ed. by Moss, R. A.; Jones, M., Jr., Wiley, New York, 1983; Vol. 3, p. 336.
- [2] 吴世群, 武戈, 陶凤岗, 林子森, 科学通报, 1983, 32, 243.
- [3] Tortorelli, V. J.; Jones, M., Jr.; Wu, S.-H.; Li, Z.-H., *Organometallics*, 1983, 2, 759.

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CSO: 4009/1053

FIRST-ORDER DERIVATIVE SPECTROPHOTOMETRIC DETERMINATION OF MICRO-AMOUNT OF ZIRCONIUM IN SILVER-PALLADIUM ALLOYS WITH P-HIPPURIC ACID CHLOROPHOSPHONAZO

Beijing HUAXUE SHIJI [CHEMICAL REAGENTS] in Chinese Vol 8, No 2, 28 Apr 86
pp 76-79

[English abstract of article by Wang Qingyue [3769 7230 6460] of Shanghai Non-Ferrous Metals Research Institute]

[Text] A rapid, selective and sensitive first-order derivative spectrophotometric method for the determination of zirconium based on the color reaction with p-hippuric acid chlorophosphonazo in the presence of OP has been developed. The suitable acidity for the formation of the stable complex is 0.004~2.0 N of hydrochloric acid. The zirconium to ligand ratio is 1:2. More than 50 kinds of substances do not interfere the determination of zirconium. The procedure can be applied to the direct determination of 0.05~0.8 percent zirconium in Ag-Pd alloys. (Paper received 17 Dec 84.)

SYNTHESES AND PROPERTIES OF MACROPOROUS CHELATE RESINS OF CROSSLINKED DITHIO-CARBOXYLATED POLYVINYL BENZYLAMINE AND ITS OXIDIZED PRODUCT

Beijing HUAXUE SHIJI [CHEMICAL REAGENTS] in Chinese Vol 8, No 2, 28 Apr 86
pp 80-84

[English abstract of article by Chen Yigong [7115 5030 6978], et al., of Department of Chemistry, Hangzhou University; Cheng Xinliang [4453 0207 5328], et al., of Department of Rock Chemistry, Chang Chun Geology College]

[Text] The title resins bearing-NHCSSNa (1) and -NHCSS-SSCNHO (2) group with high content of the functional group were prepared. The high conversion of the functional groups was confirmed by IR-spectra and elementary analysis.

The adsorption capacities of resin (1) and resin (2) for Cu^{2+} , Zn^{2+} , Ni^{2+} , Co^{2+} , Ag^{+} , Hg^{2+} , Cd^{2+} , Pb^{2+} , Au^{3+} are 4.07~0.51 and 3.81~0.59 meq ion/g, respectively. The influences of pH, adsorption time on the percentage of ion adsorption and adsorption selectivities were determined. The adsorbed Cu^{2+} , Pb^{2+} , Cd^{2+} , Co^{2+} , Ni^{2+} ions can be quantitatively eluted by 5N HNO_3 . Large amount of Ca^{2+} , Mg^{2+} , Fe^{3+} , Al^{3+} did not interfere with the elution. (Paper received 15 Aug 84.)

REFERENCES

- [1] G. A. Thorn, and R. A. Ludwig, <The Dithiocarbamates and Related Compounds>, Elsevier, New York, (1972)
- [2] J. F. Dingman, Jr., K. M. Gloss, E. A. Milano, and S. Siggia, *Anal. Chem.*, 46(6), 774 (1974)
- [3] 陈义德、顾振梅, 化学试剂, 2(4), 214 (1980)
- [4] 陈义德、顾振梅, 高分子通讯, (6), 443(1982),
Chen Yiyong, and Gu Zhenmei, *Polymer Commun.*, 1(2), 152 (1983)
- [5] T. Saegusa, S. Kobayashi, K. Hayashi, and A. Yamada, *Polym. J.*, 10(4), 403 (1978)
- [6] 钱庭宝、李春荣、王补森、朱端慧、宋福云、何炳林, 化学试剂, 3(4), 193 (1981)
- [7] R. M. Barnes, and J. S. Genna, *Anal. Chem.*, 51(7), 1085 (1979)
- [8] M. B. Colella, S. Siggia, and R. M. Barnes, *Anal. Chem.*, 52(6), 967 (1980)
- [9] A. Miyazaki, and R. M. Barnes, *Anal. Chem.*, 53(2), 299 (1981)

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CSO: 4009/1069

PHOTOINITIATION ACTIVITIES OF SOME BENZOIN ALKYL ETHERS

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 85 pp 60-64

[English abstract of article by He Yi [0149 1355], Wang Lichang [3769 0500 2490], Liang Zhaoxi [4731 0340 3556], and Li Manfu [2621 2581 1318] of the High Polymer Research Institute]

[Text] Using benzoïn alkyl ethers as photoinitiators, the polymerization of n-butyl methacrylate was carried out in bulk. The polymerization rates were measured by a dilatometer. The determined photoinitiation activities of the photoinitiators were in order as follows: Benzoïn Methyl ether>benzoïn ethyl ether>benzoïn isopropyl ether>alpha-hydroxymethyl benzoïn methyl ether>benzoïn>benzil>ethylene ketal. The abilities are related to their alpha-substituted groups participating in conjugation. (Paper received June 1984.)

References:

- [1] R.C. Stephen et al, *J. Macromol. Sci.—Chem.*, A14(1980), 1, 69.
- [2] H.G. Heine und H.J. Traenckner, *Progress in Org. Coatings*, 3(1975), 115.
- [3] S.E. Young, *Progress in Org. Coatings*, 4(1976), 225.
- [4] S. Peter Pappas, *Progress in Org. Coatings*, 2(1973/74), 342.
- [5] Hendrik J. Hageman et al., *macromol. Chem.*, 180(1979), 2531.
- [6] 陈用烈、梁兆熙等, 中山大学学报 (自然科学版), 1983, 3, 114.
- [7] 王尔奎、李妙贞等, 高分子通讯, 1981, 5, 381.
- [8] 蔺明谦, 有机化合物的同系线性规律, 科学出版社, 1980年, 350—352.

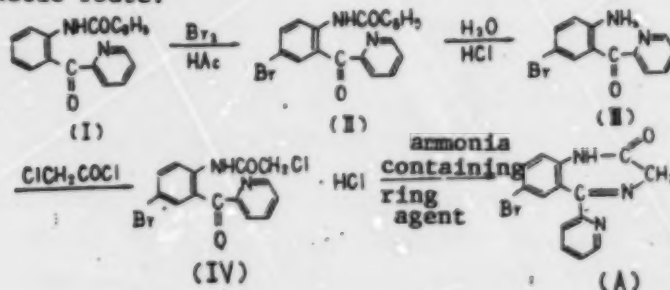
NEW SYNTHESIS OF BROMAZEPAM

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 85 pp 115-118

[English abstract of article by Ying Baining [5391 2672 1380], Zhong Zengpei [6988 1073 1014], and Chen Bailing [7115 2672 2651] of the Chemistry Department]

[Text] Improvements in procedures were made for the synthesis of bromazepam (7-bromo-5-(2-pyridyl)-3H-1, 4-benzodiazepine-2 (1H)-one) in high yield, 2-(2-amino-5-bromo-benzoyl) pyridine was prepared by bromination, followed by hydrolysis. The hydrochloride of 2-(2-chloroacetamino-5-bromo-benzoyl) pyridine could be separated as an intermediate before the ring closure to form bromazepam. (Paper received May 1984.)

Synthetic route:



References:

- (1) Leickert, K. H., *Meb. Welt.*, 28 (1977), 1317-1321.
- (2) Michael, J., Ierodiakonou, C., Mavropoulos, T., Diakoyiannis, A., *Helliniatr.*, 46 (1977), 172-179.
- (3) U. S. part. 3,100,770 (1963); U. S. part. 3,182,065 (1965); U. S. part. 3,182,065 (1965).
- (4) R. Ian Fryer, R. A. Schmidt and L. H. Sternbach, *J. Pharm. Sciences*, 57(1968), 3, 264, 3.
- (5) U. S. part. 3,182,067.
- (6) U. S. part. 3,886,141.
- (7) M. Yamamoto, S. Inaba and H. Yamamoto, *Chem. Pharm. Bull.*, 26(1978), 6, 1673-1681.
- (8) 英柏宁、钟增培等, *医药工业* 1984, 2, 39.

Dynamics

NEW METHOD FOR INTERFACE DYNAMIC INVESTIGATION IN SOLID STATE PHASE TRANSFORMATIONS

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 85 pp 45-49

[English abstract of article by Zhang Jinxiu [1728 6651 0208] and Li Xiejun [2621 3610 0971] of the Physics Department]

[Text] There are two forces, phase transition driving force ΔG and resistant force, exerting on the moving interface in the process of solid state phase transformation (SSPT). The interface moves when the driving force ΔG reaches a critical value ΔG_R to overcome the resistant force. It is reasonable to postulate the average velocity of moving $\Delta G' = \Delta G - \Delta G_R$, i.e. $V = \varphi(\Delta G - \Delta G_R) = \varphi(\Delta G')$. Starting from the elementary consideration of solid state transition theory and internal friction theory, the relation between interface dynamic function $V = \varphi(\Delta G')$ and some physical parameters was obtained as

$$c \frac{d \ln \varphi(\Delta G')}{d \Delta G'} = Q^{-1} \omega / \mu \frac{dF}{d\xi} \frac{d\xi}{dt}$$

where c is a coupling coefficient, Q^{-1} is the internal friction in the process of SSPT, ω is the frequency of vibration of the specimen in the internal friction measurement process, μ is modulus, $\frac{dF}{d\xi}$ is transformation rate and $\frac{d\xi}{dt}$ is the varying rate of the acting field. All the parameters in the right side are measurable. So, it is possible to drive the dynamic function $V = \varphi(\Delta G - \Delta G_R)$ from experimental data.

The possible applications of this method to the investigation of SSPT were discussed and some application examples were listed. (Paper received August 1984).

- References:
- (1) 冯端, 物理, 1984, 3, 1.
 - (2) T. H. O'Dell, Ferromagnetodynamics, The dynamics of magnetic bubbles, domains and domain walls, Macmillan (1981), Chapt., 1-2.
 - (3) 徐祖端, 马氏体相变和马氏体, 第四章, 科学出版社, 1980.
 - (4) 张进修, 中山大学学报(自然科学版), 1982, 3, 1; *J de Physique*, 42 (1981), C5-399.
 - (5) 王业宁等, 南京大学学报(自然科学版), 7 (1963), 3; 高等学校自然科学学报(物理学报), 1965, 试刊第五期, 352.
 - (6) O. Mercier et al., *Acta Met.*, 27 (1979), 1407.
 - (7) 夏伍戎、水嘉鹏、王子孝、周如松, 武汉大学学报(自然科学版), 1983, 3, 41.
 - (8) F. Wollants et al., *Zeit. Metallkde.*, 70 (1979), 113.

A HIGH SPEED NMOS PARALLEL MULTIPLIER

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86 pp 1-6

[English abstract of article by Mao Yuhai [5403 0060 3189] of Qinghua University, Beijing]

[Text] A new configuration of high speed parallel multiplier is presented. In this configuration, Wallace tree is used to simplify the modified Booth's algorithm. Carry save adders, suitable for NMOS implementation, are used. In the last level of two bits addition, Manchester type adder with fast carry propagation is used instead of ordinary carry look-ahead adder. A new NMOS realization of Manchester adder is presented. The total gate count of this high speed parallel multiplier is less than that of the ordinary multiplier with modified Booth's algorithm. The time of multiplication is also reduced. Furthermore, the configuration of CSA array is much more regular. It is especially suitable for VLSI layout design. (Paper received Feb 85, finalized Apr 85.)

REFERENCES

- [1] D. J. Geist: MOS Processor picks up speed with bipolar multipliers, Electronics, P.113, July 1977.
- [2] O. L. MacSorley: High-speed arithmetic in binary computers, Proc. IRE, Vol. 49, pp.87-91, Jan.1961.
- [3] C.S. Wallace: A suggestion for a fast multiplier, IEEE Trans., Vol. EC-13, pp.14-17, Feb.1964.
- [4] A. D. Booth: A signed binary multiplication technique. Quart. J. Mech. Appl. Math. Vol.4, Part 2, 1951.
- [5] L. P. Rubinfield: A Proof of the modified Booth's algorithm for multiplication, IEEE Trans., Vol.C-24 pp. 1014-1016, Oct.1975.
- [6] S. Waser: High-speed monolithic multipliers for real-time digital signal processing. Computer, pp.19-29, Oct. 1978.
- [7] R. T. Masumoto: The design of a 16×16 Multiplier, LAMBDA pp.15-21, First Quarter, 1980.
- [8] C. Mead, L. Conway: Introduction to VLSI Systems. Addison-Wesley Publishing Co., 1980.
- [9] T. Kilburn, D. B. G. Edward, D. Aspinall: A parallel arithmetic unit using a saturated transistor fast-carry circuit, Proc. IEE. pt.8, Vol.107, pp.573-584, Nov. 1960.
- [10] C. P. Lerouge, P. Girard, J. S. Colardelle: A fast 16 bit NMOS parallel multiplier, IEEE J. of Solid-State Circuits, Vol. SC-19, No.3, pp. 338-342, June 1984.

A THEOREM OF THE INVARIANCE OF THE SCATTERING MATRIX OF N-PORT NETWORKS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86 pp 7-14

[English abstract of article by Huang Xiangfu [7806 7449 7450] and He Shide [6320 1597 1795] of Chengdu Institute of Radio Engineering]

[Text] A new theorem of the invariance of the scattering matrix of n-port networks is proposed and proved. The theorem is useful in the analysis and design of electrical networks, and some of its applications are mentioned briefly. (Paper received Jan 85, finalized Aug 85.)

REFERENCES

- [1] Wai-kai Chen: Theory and Design of Broadband Matching Networks, Pergamon Press, New York, 1976.
- [2] H. J. Carlin, B. S. Yarman: IEEE Trans. on CAS, No. 1, pp. 15-28, 1983.
- [3] B. S. Yarman, H. J. Carlin: IEEE Trans. on MTT, No. 12, pp. 2216-2222, 1982.
- [4] 黄香腹: 宽带匹配网络, 电子工业出版社, (待出版)。
- [5] H. J. Carlin: IEEE Trans. on CAS, No. 4, pp. 170-175, 1977.
- [6] H. J. Carlin, J. Komiak: IEEE Trans. on MTT, No. 2, pp. 93-99, 1979.

GENERALIZED EVEN-ODD MODE EXPANSION AND THINNING TECHNIQUE FOR COMPUTATION OF WIRE ANTENNAS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86 pp 14-18

[English abstract of article by Liang Changhong [2733 2490 3163] and Meng Zhiqi [1322 1807 1142] of Northwest Telecommunication Engineering Institute, Xian]

[Text] A new method for computation of wire antennas is discussed. In case of symmetrical geometry of wire antennas or arrays with any voltage excitation, generalized even-odd mode expansion method can be used. This method and judicious applications of thinning technique will save about half computation time without sacrificing the specified accuracy. Some examples are given. (Paper received Jan 85, finalized Apr 85.)

REFERENCES

- [1] D. K. Cheng, C. H. Liang: Thinning technique for moment method solutions, Proc. IEEE, Vol. 71, No. 2, pp. 265-266, Feb. 1983.
- [2] R. F. Harrington: Field Computation by Moment Methods, New York, Macmillan, 1968.
- [3] S. Barnett: Matrix Method for Engineers and Scientists, McGraw-Hill Book Company(UK), 1979.
- [4] D. K. Cheng, C. H. Liang: Shaped wire antennas with maximum directivity, Electronics Letters, Vol 18, No. 19, pp. 816-818, Sept. 1982.

THE AR SPECTRAL ESTIMATE ALGORITHM OF CANCELLING NOISE EFFECTS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86 pp 33-40

[English abstract of article by Yu Huili [0151 6540 6849] of No. 634 Research Institute, Ministry of Aviation Industry, Beijing]

[Text] AR series obtained by observation, as they are mixed with observed noise, often reduce greatly both the resolution and the estimating performance of AR spectral estimation. The recursive algorithm of Householder transform is applied for AR spectral estimation by forming the high-order autocorrelation matrix, and an unbiased estimation of AR parameters is obtained. Thus, the noise pollution to AR spectral is overcome and a better estimation performance is ensured. (Paper received Dec 84, finalized Jun 85.)

REFERENCES

- [1] S. M. Kay: The effects of noise on the autoregressive spectral estimator, IEEE Trans., Vol. ASSP-27, pp. 478-485, Oct. 1979.
- [2] S. M. Kay, S. L. Marple: Spectrum analysis—A modern perspective, Proc. of IEEE, Vol. 69, No. 11, Nov. 1981.
- [3] P. D. Scott, C. L. Nikias: Energy-weighted linear predictive spectral estimation, IEEE Trans., Vol. ASSP-30, pp. 287-292, Apr. 1982.
- [4] S. M. Kay: Noise compensation for autoregressive spectral estimation, IEEE Trans., Vol. ASSP-28, pp. 292-303, June 1980.
- [5] J. A. Cadzow: High performance spectral estimation—a new ARMA method, IEEE Trans., Vol. ASSP-28, pp. 524-529, Oct. 1980.
- [6] J. M. Melsa, J. S. Tomcik: Linear predictive coding with additive noise for application to speech digitization, in Proc. 14th Allerton Conf. Circuits and Systems Theory, pp. 500-508, Sept. 1976.
- [7] Y. T. Chan and R. P. Langford: Spectral estimation via the high-order Yule-Walker equations, IEEE Trans., Vol. ASSP-30, pp. 680-698, Oct. 1982.
- [8] 冯康等,《数值计算方法》,国防工业出版社,1978。
- [9] 黄俊钦,张继志,一种同时估计模型阶次与参数的算法,仪器仪表学报, No. 4, pp. 330-342, 1984.
- [10] 黄俊钦,余辉里,一种新的AR谱估计算法,全国数字信号处理学术会议论文集,1984.
- [11] S. L. Marple: A new autoregressive spectral analysis algorithm, IEEE Trans., Vol. ASSP-28, pp. 441-454, Aug. 1980.

THE LOCAL ACCURACY OF MEAN SQUARED DIFFERENCE TEMPLATE MATCHING SYSTEMS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86
pp 48-53

[English abstract of article by Peng Jiaxiong [1756 0857 7160] of Institute of Pattern Recognition and Artificial Intelligence, Huazhong University of Science and Technology]

[Text] Under the conditions that the signal and noise are two independent, mean square differentiable two-dimensional homogeneous Gaussian random fields and the mathematical expectation of noise is zero, the three important properties of mean squared difference template matching systems are proved, and the local accuracy estimation formulas of the contain-wise and pass-wise two matching manners are derived. When the integral distance, autocorrelation functions of signal and noise are known, the local accuracy for a system can be analytically computed and evaluated. (Paper received Dec 84, finalized Sep 85.)

REFERENCES

- [1] G. J. Vanderbrug, A. Rosenfeld: Two-stage template matching, IEEE Trans., Vol. C-26, No. 4, pp.384-393, 1977.
- [2] B. V. K. Vijaya Kumar, D. Casasent: Binarization effects in a correlator with noisy input data, Applied Optics, Vol. 20, No.8; pp.1433-1437, 1981.
- [3] H. K. Ramapriyan: A multilevel approach to sequential detection of pictorial features, IEEE Trans., Vol. C-25, No.1, pp.66-78, 1976.
- [4] L. D. Hostettler: An analysis of terrain-aided inertial navigation system, SAND75-0299, Sept. 1975.
- [5] P. R. Hinrichs: Advanced terrain correlation techniques, IEEE 1976 Position Location and Navigation Symp., pp.89-96, 1976.
- [6] D. A. Fogle, R. H. Goebel: The two-dimensional accuracy of a one-dimensional correlator, Proc. of 1976 IEEE Southeastcon Region 3 Conf., pp.230-232, 1976.
- [7] 彭嘉雄, 张天序: 随机离散图象的统计模型研究, 自动化学报, Vol.10, No.1, pp.16-21, 1984.
- [8] P. Swerling: Statistical properties of the contours of random surfaces, IRE Trans., Vol. IT-8, No.4, pp.315-321, 1962.
- [9] A. P. 塞奇, J. L. 梅尔萨: 估计理论及其在通讯与控制中的应用, 科学出版社, pp.76-82, 1978.
- [10] T. Assefi: Stochastic Processes and Estimation Theory with Applications, John Wiley & Sons, pp.36-69, 1979.

COMPOUND ORDER FILTERING FOR BINARY SEQUENCE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86
pp 76-81

[English abstract of article by Wu Minjin [0702 2404 6855] of East China Normal University]

[Text] The distribution functions and statistical correlation properties of compound order filtering for binary sequence (i.i.d.) are investigated. Their applications to waveform analysis and image processing are also discussed. (Paper received Apr 84, finalized Aug 85.)

REFERENCES

- [1] 万嘉若、吴敏金, Minkowski结构运算与顺序滤波, 自动化学报, No.1, 1984.
- [2] T. S. Huang: Two-Dimensional Digital Signal Processing I, Wiley, New York, 1981.
- [3] J. Serra: Stereology and Structuring Elements, Journal of Microscopy, 1972.
- [4] 吴敏金: 复合极值的统计特性及其应用, 华东师大学报, No.2, 1985.
- [5] H. A. David: Order Statistics, Wiley, New York, 1970.
- [6] 吴敏金: 递归算法与复合极值分布, 上海市计算机应用资料汇编, 第十期.

ACCURATE SOLUTION OF ELLIPTICAL AND CYLINDRICAL STRIPLINES AND MICROSTRIP LINES

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86
pp 82-88

[English abstract of article by Zeng Lingru [2582 0109 0320] of Beijing Institute
of Tracking Telemetry and Control]

[Text] Accurate solutions of elliptical and cylindrical striplines and microstrip lines are presented. The geometric figures of the elliptical and cylindrical striplines are conformally transformed into asymmetric and symmetric planar striplines, and the elliptical and cylindrical microstrip lines into planar microstrip lines, yielding the formulae for exactly calculating characteristic impedances of the six lines, of which one is new. (Paper received Nov 84, finalized Apr 85.)

REFERENCES

- [1] Wang Yen-Chu: IEEE Trans., Vol. MTT-26, p.20, Jan. 1978.
- [2] Joshi, K. K. and Das, B. N.: IEEE Trans., Vol. MTT-28, p. 381, April 1980.
- [3] Rao, J. S. and Das, B. N.: IEEE Trans., Vol. MTT-27, p.299. April 1979.
- [4] Byrd, P. F. and Friedman, M. D.: Handbook of Elliptic Integrals for Engineers and Physicists, 1954.
- [5] Hilberg, W.: IEEE Trans., Vol. MTT-17, p.259, May 1969.
- [6] Cohn, S. B.: IRE Trans., Vol. MTT-2, p.52, July 1954.
- [7] Waldron, R. A.: IEEE Trans., Vol. MTT-12, p.123, 1964.
- [8] Richardson, J. K.: IEEE Trans., Vol. MTT-15, p.130. Feb. 1967.
- [9] Wheeler, H. A.: IEEE Trans., Vol. MTT-13, p.172, Mar. 1965.
- [10] Schneider. M. V.: B. S. T. J., Vol. 48, p.1421, May-June 1969.

A QUASI-LINEAR ANALYSIS OF PHASE LOCKED LOOPS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86
pp 89-94

[English abstract of article by Tian Xiaowen [3944 1321 2429] of Chengdu Institute of Radio Engineering]

[Text] A new model of PLLs is given. Linear analysis of PLLs can be developed in a larger range with the new model. The analysis gives enough precision for engineering use for a PLL with arbitrary characteristic phase detector $g(\varphi)$, which runs in whole positive slope range of $g(\varphi)$. (Paper received Aug 84, finalized Jul 85.)

REFERENCES

- [1] W. C. Lindsey: Synchronization System in Communication and Control, Prentice-Hall, Englewood Cliffs, NJ, 1972, Chap. 4.
- [2] A. J. Viterbi: Acquisition and tracking behavior of phase locked loops, Proceeding of the Symposium on Active Networks and Feedback Systems, April 1980. Symposia Series, Vol. X, pp. 583-610.
- [3] F. M. Gardner: Phaselock Techniques, New York, John Wiley, 1979, second edition, Chap. 4.
- [4] 成都电讯工程学院一系:《锁相技术》讲义, 第11章, 1982年12月。

LASER RECRYSTALLIZATION OF MOCVD Poly-GaAs ON INSULATING SUBSTRATES

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86 pp 110-113

[English abstract of article by Bao Ximao [7637 1585 5399], et al., of Nanjing University, Jiangsu]

[Text] Polycrystalline GaAs films are grown successfully on insulating substrates by MOCVD technique. The film is flat and bright, close in texture, and has stoichiometry of GaAs. The poly-GaAs films were recrystallized with grain size changed from 200Å to to μm when scanned by CW Ar⁺ laser beam. The schottky barrier diodes are fabricated on the laser recrystallized GaAs film. (Paper received Jul 84, finalized Jan 85.)

REFERENCES

- [1] J. F. Gibbons and K. F. Lee: IEEE Vol. EDL-1 p. 6, 1980.
- [2] 古川静二郎, 电子材料, No. 22, p. 105, 1983.
- [3] 邹世昌、沈宋南等, 电子学报, Vol. 11, No. 5, p. 1, 1983.
- [4] 鲍希茂、柳承恩等, 南京大学学报, Vol. 2, p. 229, 1983.
- [5] H. M. Manasevit and W. I. Simpson: J. Electronem. Soc., Vol. 116, p. 1725, 1969.
- [6] T. Nakanisi, T. Udagawa et al.: J. Crystal Growth, Vol. 55, No. 1, p. 255, 1981.

THERMOELECTRIC POWER MEASUREMENT OF AMORPHOUS III-V COMPOUNDS SEMICONDUCTORS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86
pp 114-116

[English abstract of article by Liu Xianghui [2692 5980 2037] of Shanghai Institute of Metallurgy, Academia Sinica]

[Text] Using measurements of the thermopower and DC conductivities, the electrical properties of thin films GaAs, GaP and InP which rendered amorphous by bombardment with rare gas ions are investigated. It is shown that ion beam bombardment amorphization is an advantageous technique for studying and understanding the fundamental process in the amorphous compounds semiconductors. (Paper received Dec 84, finalized Oct 85.)

REFERENCES

- [1] A. Gheorghiu, M. L. Thèye: J. Non-Cryst. Solids, Vol. 35/36, p. 397, 1980.
- [2] M. L. Thèye, A. Gheorghiu, H. Launois: J. Phys. C: Solid State Physics, Vol. 13, p. 6569, 1980.
- [3] R. T. S. Shieh et al.: Can. J. Phys., Vol. 55 p. 265, 1977.
- [4] J. Stuke: Proc. of Intern. Conf. on Low-Mobility Materials, Eilat, Israel, p.103, 1970.
- [5] W. Beyer, J. Stuke: J. Non-Cryst. Solids, Vol. 8-10, p. 321, 1972.
- [6] D. I. Jones et al.: Phil. Mag., Vol. 36, No. 3, p.541, 1977.
- [7] W. Beyer et al.: Solar Energy Materials, Vol. 9, p.229, 1983.
- [8] X. G. Deng, X. H. Liu et al.: Appl. Phys. A, Vol. 33, p.29, 1984.
- [9] R. Pfeilsticker et al.: Nucl. Instr. Methods, Vol. 182/183, p.603, 1981.
- [10] N. F. Mott, E. A. Davis: Electronic Processes in Non-Crystalline Materials, Clarendon Press, Oxford, p.32, 1979.

THE MICROWAVE MIXER WITH IMAGE RECOVERY USING DIELECTRIC RESONATORS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86 pp 117-119

[English abstract of article by Ao Faliang [2407 4099 5328] of Guilin Institute of Electronical Technology, Guilin, China]

[Text] The microwave mixer with image recovery using dielectric resonators at X-band is presented. The design method, the real circuit and the experimental data for comparison are all discussed. The results show that the signal conversion loss is reduced by about 1dB, and the image to signal conversion loss ratio is more than 25dB. With simple circuit construction and adjustment methods, it is suitable for microwave receiver applications. (Paper received Sep 84, finalized Sep 85.)

REFERENCES

- [1] W. L. Pritchard: IRE Trans., Vol. MTT-3, pp. 37-38, Jan. 1955.
- [2] K. M. Johnson: IEEE Trans., Vol. ED-15, pp. 430-450, July 1968.
- [3] 李炳华,《固体微波》, No.1, pp. 8-11, 1979.
- [4] 王德仪等,《微波器件与电路》, p. 48, 江苏科技出版社, 1981年版。
- [5] D. Kajfez: MSN, pp 133-140, June 1982.
- [6] 吴万春,《微波网络》, 西北电讯工程学院, 1975年版。
- [7] 戴发良、张德瑞,《通信学报》, Vol.8, No.2, pp. 79-83, 1985.
- [8] 吴万春,《集成固体微波电路》, p.101, 国防工业出版社, 1981年版。
- [9] 戴发良、张德瑞, 推荐一种介质谐振器尺寸的简单计算方法, 1984年中国电子学会通讯学会微波通讯技术学术会议论文。

OHMIC CONTACT ON HIGH RESISTIVITY N-Si

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86
pp 120-122

[English abstract of article by Chen Cunli [7115 1317 4409] of Department of Physics, Nanjing University, and Chen Zhengfu [7115 2973 1133] et al., of Shanghai Electronic Devices and Materials Works]

[Text] Using a silver head electric soldering iron, the alloy consisting of In, Au, Sb and Ni in the ratio of 91:7:1:1 is directly smeared on the silicon wafer, which is then annealed at 450°C. Good quality ohmic contact is obtained even when the silicon resistivity is as high as 600Ωcm. The specific contact resistivity of metal to N-Si is calculated as a function of doping concentration and compared with experimental results. This contacting technique is successfully applied to the measurement of impurity compensation. (Paper received Nov 84, finalized Jun 85.)

REFERENCES

- [1] 陈存礼, 范仁永: 半导体学报, Vol. 4, No. 5, p. 502, 1983.
- [2] 陈存礼: 电子学报, Vol. 12, No. 3, p. 105, 1984.
- [3] 陈存礼: 稀有金属, Vol. 20, No. 5, p. 53, 1980.
- [4] A.Y.C. Yu: Solid-State Electronics, Vol. 13, No. 2, p. 239, 1970.
- [5] 陈存礼: 物理学报, Vol. 33, No. 9, p. 1314, 1984.

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CSO: 4009/1065

IMMUNOHISTOCHEMICAL OBSERVATION OF CARDIONATRIN-LIKE SUBSTANCE IN RAT LUNG

Beijing BEIJING YIKE DAI XUE XUEBAO [JOURNAL OF BEIJING MEDICAL UNIVERSITY] in Chinese Vol 18, No 2, 18 May 86 pp 81-82

[English abstract of article by Sun Minzhi [1327 2404 0037], et al., of Department of Histology and Embryology]

[Text] Highly specific anti-human atrial natriuretic peptide serum and peroxidase-antiperoxidase (PAP) immunohistochemical technique were used to demonstrate the distribution of cardionatrin in rat lung. Cardionatrin-like substance is found in part of the muscle cells of the wall of pulmonary veins and in some cells of alveolar septa. In the muscle cells it is located in the cytoplasm around the nucleus. The cells in a alveolar septa are mostly in groups. They are large, round or irregular. Their cytoplasm contains many granules of cardionatrin-like substance. The nature of such cell is to be determined.

REFERENCES

1. 孙敏之等. 大鼠心脏心房肽免疫组织化学观察. 北京医学院学报 1984; 18 (4):285.
2. Tang J, et al. Characterization and localization of atriopeptin in rat atrium. Peptides 1984; 5:1173.
3. Tang J, et al. Depressor and natriuretic activities of several atrial peptides. Regulatory Peptides 1984; 9:53.
4. Tang J, Xie CW. Cardionatrin-A new brain, heart and lung peptides (plenary lecture) 7th conference of neuroscience, Hong Kong 1985; P4a.
5. Sternberger LA. Immunocytochemistry. 2nd ed. John Willy and sons Inc NY. 1979:124-126.

(本文图见插页第5页)

Lasers

COMPUTER ANALYSIS BY LENS ARRAY FOR UNIFORM ILLUMINATION

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 2,
20 Feb 86 pp 65-70

[English abstract of article by Chen Zezun [7115 3419 1415], et al., of Shanghai
Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] It is advantageous to use lens array for uniform illumination of high-power laser targets¹. By using the computer analysis of the optical field on the targets, the characteristics of this way have been studied. In the present report, we propose a star-shaped arrangement of the concentricity deviation of the lens array elements. This enables us to concentrate the two-dimensional interference pattern and can meet the requirements of the uniformity and experiments.

STUDY ON TWO PHYSICAL MECHANISMS FOR HIGH ORDER COHERENT RAMAN RADIATION

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 2,
20 Feb 86 pp 71-75

[English abstract of article by He Guangsheng [6378 0342 3932], et al., of
Shanghai Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] High order coherent Raman radiation caused by two different mechanisms in the stimulated Raman scattering experiments have been studied. One is the cascade stimulated scattering process, the other is Raman-resonance enhanced four-wave mixing which is characterized by phase matching condition and causes a hollow ring distribution in the near-field. Experimental results judgement using calcite sample have shown that these two physical processes can appear separately or simultaneously depending on the experimental conditions.

GAIN CHARACTERISTICS OF FREE-ELECTRON LASERS USING SMITH-PURCELL EFFECT

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 2, 20 Feb 86 pp 80-85

[English abstract of article by Zhang Dake [1728 1129 0668] of Shanghai Institute
of Optics and Fine Mechanics, Academia Sinica]

[Text] Coupled-mode approach and electron Bloch equations are combined to
calculate the gain of free-electron lasers using Smith-Purcell effect in the
gain quantum model. The possibility of increasing gain by changing the spa-
tial frequency of the grating is studied.

INSTRUMENTATION FOR RAPID DETERMINATION OF REFLECTIVE AND TRANSMISSIVE SPECTRA

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 2,
20 Feb 86 pp 99-103

[English abstract of article by Wang Bingkui [3769 3521 1145], et al., of Fudan University]

[Text] An effective and precision apparatus for rapid determination of optical reflective and transmissive spectra is described. By using a rapid rotating optical fiber to sample the incident and reflected or transmitted light beams respectively and feedback of the incident beam intensity to monitor the gain of the photomultiplier for keeping the incident photo-current under constant level, the measured signal gives the transmissivity or reflectivity directly. Besides, due to rapid scanning of the sampled signals the requirement on the steadiness of the light source is not critical. The relative accuracy of the measurements in the range of 410nm to 650nm is less than 2 percent and the time for scanning the complete visible spectrum is 2 minutes.

LARGE CURRENT RECTANGULAR PULSED LASER POWER SUPPLY

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 2,
20 Feb 86 pp 112-115

[English abstract of article by Xue Bin [5641 1755], et al., of Department
of Precision Instruments, Tianjin University]

[Text] By combining thristor switch with large power transistor, large current
rectangular pulsed laser power supply with stable smooth top is obtained, pulsed
current of 80A and top current fluctuation within 2 percent are achieved.

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CSO: 4009/88

RELATIVE DISTRIBUTION AT FOCAL PLANE OF LOW-ORDER MODES FOR GAUSSIAN LASER BEAMS

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 6, 20 Jun 86 pp 321-327

[English abstract of article by Cheng Zhaogu [4453 0340 6253] and Wang Runwen [3769 3387 2429] of the Shanghai Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] Analytic resolution for relative energy distribution at focal plane of low-order modes for Gaussian laser beams is given. The results are compared with the focal properties at far-field of single mode light for unstable cavity with different magnification M . With 80 percent of total laser energy at focal plane as the united criterion of beam divergence, calculation indicates that with stable cavity for mode-selection, one can obtain good beam quality which may be close, even superior, to that for mode-selection for unstable cavity under some conditions. Moreover, the stable cavity construction is simple, the cavity is more stable and the electro-optic efficiency is high as well.

SELF-HEATED 20 W DISCHARGE COPPER VAPOR LASER

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 6, 20 Jun 86 pp 334-337

[English abstract of article by Liang Baogen [2733 1405 2704], et al., of Shanghai Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] Output characteristics of our self-heated discharge copper vapor laser are reported. The maximum average power is 20.5 W with an efficiency of 1.5 percent. Luminescence performances of the device are measured and discussed.

A METHOD OF SEARCHING FOR WORKING MATERIALS OF OPTICALLY PUMPED FIR LASERS

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 6,
20 Jun 86 pp 341-347

[English abstract of article by Xu Fuyong [6079 4395 3057], et al., of Department of Radio Physics and Computer Science, Lanzhou University]

[Text] The mechanism of the known working materials for optically pumped FIR lasers is explained on the basis of the physical model of di-group vibration and linear tri-group vibration. Mathematical derivation shows a fairly good result. Based on this result a method of searching for working materials of optically pumped FIR lasers is obtained.

LASER-EXCITED FLUORESCENCE SPECTRA OF OH RADICALS IN C_2H_2 /AIR FLAME

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 6, 20 Jun 86 pp 348-350

[English abstract of article by Wang Dadi [3769 1129 0966] and Jiang Zhankui [5592 0594 7608] of Department of Physics, Jilin University]

[Text] Laser-excited UV fluorescence spectra of OH radicals at transition $A^2\Sigma^+-X^2\Pi$ in C_2H_2 /air flame have been measured. All lines in 0-0, 1-0, 2-1 bands obtained are in very good agreement with those by other methods, thus the present work provides useful data for temperature detection of flame. We have also determined the OH concentration distribution at different heights of the flame.

DIODE LASER DERIVATIVE SPECTROSCOPIC TECHNIQUE AND STUDY OF $\text{CH}_3\text{CH } \nu_4$ BAND

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 6,
20 Jun 86 pp 351-355

[English abstract of article by Yang Xueming [2799 1331 2494], et al., of Dalian
Institute of Chemical Physics, Academia Sinica]

[Text] Diode laser derivative spectroscopy of $\text{CH}_3\text{CN } \nu_4$ band is reported here
for the first time. About 120 lines of ν_4 band of the molecule were recorded
by means of the second order derivative spectroscopic technique. With an im-
proved least square fitting technique, improved parameters of ν_4 band were
obtained. And some properties of diode derivative spectroscopic technique
were discussed.

GROWTH OF $K_3Pr(PO_4)_2$ CRYSTALS

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 6,
20 Jun 86 pp 362-364

[English abstract of article by Hong Guangyan [3163 1639 6056], et al., of
Changchun Institute of Applied Chemistry, Academia Sinica]

[Text] The crystals of $K_3Pr(PO_4)_2$ have been grown from a KF-KCl flux. The influence of the flux evaporation on the crystal yield is given. The chemical analysis and X-ray diffraction pattern confirmed that the crystal was $K_3Pr(PO_4)_2$. The infrared, absorption and fluorescence spectra have been determined.

DETECTION SYSTEM FOR TIME RESOLVED WEAK SIGNALS IN LASER SPECTROSCOPY

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 6, 20 Jun 86 pp 365-367

[English abstract of article by Ye Lili [0673 7787 7787], et al., of Anhui
Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] A transient digitizer is combined with a multichannel analyzer to form a multichannel averaging system. This system has faster response time and higher accumulation velocity than normal multichannel signal averagers. It has been used in some simulating experiment and laser-induced fluorescence measurement of CH₄.

INVESTIGATION OF WHITE LIGHT HOE--REFLECTION HOLOGRAPHIC LENS FOR VISUAL DISPLAY APPLICATIONS

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 6, 20 Jun 86 pp 368-372

[English abstract of article by Xu Kunxian [1776 2492 6343] of Shanghai Institute of Laser Technology]

[Text] Off-axial reflection holographic visual display elements which records in dichromated gelatin (DCG) deposited on planar substrate of glass has been developed for pilot headup display (HUD). Important image characteristics such as diffraction efficiency, aberrations, dispersion, distortion and optical transfer function (OTF) etc for the off-axial reflection holographic lens are analysed. Preparation and processing of DCG film and several important techniques for obtaining high quality holographic lens are recommended.

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CSO: 4009/86

ON THE DIOPHANTINE EQUATION $P^2 - 2Q^2 = -1$

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese No 2, 1986 pp 1-9

[English abstract of article by Qu Minghua [1448 2494 5478]]

[Text] This paper considers the equation

$$p^2 - 2q^2 = -1, \quad p, q \text{ prime} \quad (1)$$

which arose by Grescenzo P. Using some properties of pell number, we have proved following theorems.

Th 1. Let $q \equiv 1 \pmod{8}$ is a prime. If $q = u^2 + 2^2$ and $8 \nmid u$ then for arbitrary prime p , (p, q) is not a solution of equation (1)

Th 2. 1) If $p = u^2 + 2v^2 \equiv 9 \pmod{16}$ is a prime and $8 \nmid v$ then for arbitrary prime q (p, q) is not a solution of equation (1)

2) Let $p = c^2 + 128d^2 \equiv 17 \pmod{32}$ is a prime. Hence $p = a^2 + 64b^2$. If $b + d \equiv 1 \pmod{2}$, then for arbitrary prime q , (p, q) is not a solution to equation (1).

Th. 5. (1) has only three solutions, which satisfy that $p, q < 10^{15}$: $(7, 5)$, $(41, 29)$, $(63018038201, 44560482149)$ (Paper received 12 Jan 85.)

REFERENCES

- [1] Grescenzo P. Advance Math 17(1975), 25—29.
- [2] 柯召、魏万迪. 组合论 (上册), 科学出版社, 1984, 132.
- [3] V.Thebault. Sur des suites de pell. Mathesis 65(1956), 3^o0—395.
- [4] P.Barrucand and H.Cohn. J.Reine Angew Math. 238(1969) 67—70.
- [5] Erich Hecke. Lectures on the theory of algebraic numbers. Springer-Verlag New York Inc. 1981 196.
- [6] Emma Lehmer. J.Reine Angew Math 268/269(1974), 294—301.

MONTE CARLO SIMULATION OF THE PRIOR PROBABILITY ESTIMATION IN DDR

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese No 2, 1986 pp 85-92

[English abstract of article by Zhang Yongke [1728 3057 4430] and Guo Xiaofeng [6753 2556 1496]]

[Text] In this paper, two methods (SAMK and SAMD) of estimating the prior probability in DDR (Decission-Directed Receiver) are discussed and compared in detail. The experimental simulations are made on both methods by Monte Carlo technique when SNR is not too small, satisfactory results are obtained. The improved SAMD method presented in this paper showed its simplicity in simulation. (Paper received 31 Jan 85.)

REFERENCES

- [1] L.D.Davisson and S.C.Schwartz, IEEE Trans., IT-16(1970),270.
- [2] D.Kazakos and L.D.Davisson, IEEE Trans., IT-26(1980),113
- [3] J.Sacks, Ann.Math.Stat., 29,(1958),373
- [4] 中国科学院计算中心概率统计组, 概率统计计算, 科学出版社, 1983.
- [5] Jalalinasab and J.A.Bucklew, IEEE Trans., IT-29(1983),619.
- [6] D.D.Falconer, IEEE Trans., IT-17(1971), 336.
- [7] Z.Y.Young and G.Coraluppi, IEEE Trans., IT-16(1976),258.

Mathematics

DISCRETE PHENOMENA IN UNIQUE SOLVABILITY FOR GOURSAT'S PROBLEMS OF HYPERBOLIC SYSTEM OF SECOND ORDER

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 85 pp 11-17

[English abstract of article by Wu Ciqian [0702 5417 3383, Xuan Qiwo [8983 0796 3087] of the Computer Science Department, and Zhong Jukang [6988 6880 1660] of the Huanan Institute of Technology]

[Text] We have proved that the unique solvability for a class of Goursat's problems of the hyperbolic system of second order disappears if and only if the parameters of the system satisfy a certain coupling relation. (Paper received May 1984)

References:

- [1] F. Trèves, *Proc. Amer. Math. Soc.* 46(1974), 229—233.
- [2] 华罗庚、吴兹潜、林伟, 二阶两个自变数两个未知函数的常系数线性偏微分方程组, 科学出版社, 1979.
- [3] 吴兹潜, 褚启沃, 函数矩阵方程与波的有限传播法, 中山大学学报(自然科学版) 1984, 1.

CONSTRUCTION, APPLICATION OF CLASS FUZZY CONTROL MODEL

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 85 pp 38-44

[English abstract of article by Lin Deheng [2651 1795 5899], Chen Jieru [7115 3381 1172], and Lin Xunliang [2651 8113 0081] of the Radio Electronics Department]

[Text] A class Fuzzy control model which is constructed by means of standardization method is described. It is very convenient that the model is implemented on microcomputer and the model is selected according to various requirements of processes. Examples of application of the model and the results obtained from digital simulation are also given. (Paper received in August 1984.)

References:

- [1] Zadeh, L.A., *Information and Control*, 8(1965), 338.
- [2] King, P.J. and Mamdani, E.H., *Automatica*, 13(1977), 235.
- [3] Tong, R.M., *Automatica*, 13(1977), 559.
- [4] 李宝毅、刘志俊, 自动化学报, 6(1980), 25.
- [5] 菅野道夫, 模糊集合与模糊逻辑在控制中的应用, 叶耕中译自《计测与控制》, 18(1979), 2.
- [6] 应行仁, 模糊数学, 4(1982).

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CSO: 4009/1075

FINITE-AMPLITUDE STABILITY OF POISEUILLE FLOW IN A CIRCULAR PIPE

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 1, Jan 86 pp 64-72

[English abstract of article by Zhao Gengju [6392 5087 1133] of The Mechanics Department]

[Text] The small finite axisymmetrical disturbance in a Poiseuille flow in a circular pipe is studied. The results indicate that the finite amplitude disturbance is stable and no threshold amplitude is present. (Paper received 22 Oct 84.)

REFERENCES

- [1] 周恒, Pro. R. Soc. Lond. A381 (1982), 407-418.
- [2] Sexl, T., Ann. Phys, (1927), 83, 835.
- [3] Gill, A.E., J. Fluid Mech. (1956), 21, 145.
- [4] Davey, A. & Drazin, P.G., J. Fluid Mech. (1969), 36, 209.
- [5] Lessen, M., Sadler, S.G. & Liu, T.Y., Phys. Fluids, (1968), 11, 1404.
- [6] Tatsumi, T., J. Japan Phys. Soc. (1952), 7, 495.
- [7] Davey, A., J. Fluid Mech, (1971), 45, 701-720.
- [8] Reyholds, W.C. & Potter, M.C., J. Fluid Mech, (1967), 27, 465
- [9] Itoh, J. Fluid Mech, (1977), 82, 469-479.
- [10] Leite, R.J., J. Fluid Mech. (1959), 5, 81.
- [11] 周恒, 赵耕夫, 力学学报, (1982), 3.
- [12] Orszag, S.A. & Kells, L.C., J. Fluid Mech, (1980), 96, 159-207.
- [13] Swinney, H.L. & Gollub, J.P., Hydrodynamic Instabilities and the Transition to turbulence., (1981), 69-70, Springer-Verlag.

THE SOURCE AND QUANTITATIVE ESTIMATION OF THE SAND ACCUMULATION IN CHANNEL AT THE BAR OF THE RIVER MOUTH OUTSIDE SHANTOU PORT

Beijing HIAYANG YU HUZAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 17, No 1, Jan 86 pp 13-24

[English abstract of article by Lin Baorong [2651 1405 2837], et al., of Institute of Oceanology, Academia Sinica, Qingdao]

[Text] Sand sources of the bar at the river mouth outside the Shantou [3073 7333] Port and the dredged channel are further discussed and the accumulation is calculated roughly based on other studies and the data recently acquired. The results revealed that the bar at the river mouth outside Shantou Port just overlaps the modern ebb delta and the delta of the Xinjinxi River based on the ancient longshore bar. The development, growth and decline of it are closely related to the characteristics of the sand carried there from Xinjinxi River and by the wave and the tidal current.

The bar at the river mouth has turned to be declining after dredging a channel through it according to the sediment patterns. The volume of the sediment is on the decrease from the river mouth to the channel on the bar, and the heavy minerals can be divided into three zones: titanite, magnetite, zircon + epidote, hornblende + biotite in accordance with their specific gravities and shapes.

Its properties show that the sand was transported to the river mouth from the Xinjinxi River. Comparison of the historic charts (1907-1979) show that average annual accumulation in this area is about 560,000 m³, that on the east side of the channel accounts for 87.3 percent. However, accumulation on the west side tends to get faster, indicating that the sand was transported from east to west.

Various informations testify that the sand accumulated in the dredged channel is transported from shoal in the east side. At present, the bar of the river mouth is under a dynamic paraequilibrium with a slight accumulation. However, after the channel is dredged, the channel will be silted up gradually by the sand. The volume of the silt deposit is related to the width and depth of the dredged channel. Provided that the channel is 80m wide and -5.5 m deep, the accumulation may be estimated at 5000,000-600,000 m³/a. (Paper received 20 Oct 83.)

REFERENCES

- [1] 成都地质学院地质系, 1978. 沉积岩(物)相分析及其应用. 地质出版社, 第3页.
- [2] Сафьянов, Г. А., 1978. Береговая зона океана в XX веке. Изд. «Мир», стр. 33.

THE SEDIMENTARY ENVIRONMENTS AND CHARACTERISTICS OF THE CORAL REEF OF THE YONGXING ISLAND

Beijing HIAYANG YU HUAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 17, No 1, Jan 86 pp 36-44

[English abstract of article by Wang Guozhong [3769 0948 1813], et al., of Institute of Marine Geology, Tongji University, Shanghai]

[Text] The climate of Yongxing [3057 5281] Island, a well developed reef areas in the Xisha Islands in the South China Sea, is that of tropical monsoon. This coral reef is based on the residuum of granite-gneiss and has been developing continually since Miocene epoch.

Recent coral reef crest of the Yongxing Island is in elliptical form and ring-like. The facies on the northeast and the south-west sides are generally alike, but differ in width, number of coral genera and products of carbonate sediments. They are distributed asymmetrically as a result of asymmetrical monsoons, currents and submarine relief, while the distribution of the coral reefs in the Pacific are controlled by the trade wind.

The recent coral reef crest of the Yongxing Island appears in the following facies: the autochthonous coral reef rock facies, the reef marginal shoal gravel-boundstone facies, the reef flat sand-gravel with patch reef facies, and the cay gravel-sand facies. This reef complex is of a carbonate mound surrounded by the autochthonous reef rocks and biendstones on the reef crest. It belongs in category to the table reef. Though the sediments in the coral reef areas of the Pacific are predominantly algal debris, yet those of the Yongxing Island are absolutely dominated by the scleractinian coral and their debris. (Paper received 14 Mar 83.)

REFERENCES

- [1] 王崇友、何希贤、裘松余, 1979. 西沙群岛西永一井碳酸盐岩地层与微体古生物的初步研究. 石油实验地质 1:23-38.
- [2] 伍辉民、陈伟球, 1977. 我国西沙群岛的植物和植被. 科学出版社, 127 页.
- [3] 杨宗岱, 1982. 中国海草的生态学研究. 海洋科学 2: 34-37.
- [4] Jordan, C. F. 1978. Tropical lagoon sedimentation In: The Encyclopedia of Sedimentology (Fairbridge, R. W. and J. Bourgeois, ed.). Dowden, Hutchinson and Ross, Inc. pp. 821-828.
- [5] Levorsen, A. I. 1967. Geology of Petroleum. (2nd edition). W. H. Freeman Company, San Francisco. 724pp.
- [6] Mergner, H. and G. Scheer, 1974. The physiographic zonation and the ecological conditions of some South Indian and Ceylon coral reefs. In: Proceeding of the Second International Coral Reef Symposium. Great Barrier Reef Committee, Brisbane. pp. 3-30.
- [7] Milliman, J. D. 1974. Marine Carbonates. Springer-Verlag. Perin, Heideberg, New York, 375pp.
- [8] Tracey, J. I., J. H. S. Ladd and J. E. Hoffmeister, 1948. Reefs of Bikini, Marshall Island. Bull. of the Geol. Soc. Amer. 59: 881-899.

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CSO: 4009/1070

Organic Chemistry

A NEW METHOD FOR THE SYNTHESIS OF 2-METHOXYESTRADIOL*

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese No 2, 1986 pp 114-116

[English abstract of article by Chen Shuhua [7115 0647 5478] et al.]

[Text] A new effective method for the synthesis of 2-methoxyestradiol is described. Estradiol was brominated with NBS to give 2-bromoestradiol (II) in 36 percent yield and subsequent nucleophilic substitution of the bromo atom by methoxide ion under the catalysis of CuI(Or Cu₂O)-Crown ether in DMF at 100-105°C afforded 2-methoxyestradiol in 84 percent yield. The overall yield in the present synthetic route is higher than those have ever been reported in literature for the same target compound. (Paper received 8 Oct 84.)

REFERENCES

- [1] P. Narasimha Rao and J. E. Burdent, SYNTHESIS, 3 (1977), 168.
- [2] 陈淑华等, STEROIDS, 40(2), 1982, 123.

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CSO: 4009/1060

Orthopedics

A PRELIMINARY EXPERIMENTAL STUDY ON THE BIOLOGICAL FIXATION EFFECT OF CHINESE-MADE MADREPORIC FEMORAL HEAD PROSTHESIS

Beijing BEIJING YIKE DAI XUE XUE BAO [JOURNAL OF BEIJING MEDICAL UNIVERSITY] in Chinese Vol 18, No 2, 18 May 86 pp 91-94

[English abstract of article by Sun Xiaoli [1327 2556 7812], et al., of Department of Orthopaedics The Third Hospital]

[Text] Chinese-made madreporic Co-Cr-Mo alloy femoral head replacement was performed on 16 adult dogs. Having evaluated the data of the function recovery of hip joint, roentgenographic changes, biomechanical testing and morphological study, the authors believe that this new-type porous hip prosthesis could give excellent bone-ingrowth self-locking biological fixation. Meanwhile, the mechanical characteristics of the bone-ingrowth fixation and their relationship with function recovery of hip joint were discussed. It is hoped that this study could serve a scientific basis for clinical application of this madreporic porous hip prosthesis.

REFERENCES

1. Freeman M. A. R. Some Disadvantages of Cemented Intramedullary Stem Fixation and Their Remedies. In: Schaldach M. Artificial Hip and Knee Joint Technology. 1st ed. Berlin Heidelberg New York: Springer-Verlag. 1979;127-137.
2. Ducheyne P. et al. Influence of a Functional Dynamic Loading on Bone Ingrowth into Surface Pores of Orthopaedic Implants. J Biomed Mater Res 1977;11:811.
3. Rostoker W. et al. Effect of an in Vivo Environment on the Strength of Bone Cement. J Biomed Mater Res Symp 1979; 13:365.
4. Dana C. M. Materials and Orthopaedic Surgery. 1st ed. Baltimore: The Williams & Wilkins Company. 1979;507-510, 733-734.
5. 孙训芳等 材料力学 上册 第1版 北京: 人民教育出版社 1964; 68-78.

(本文图 1, 3, 5~13 见插图第 7 页)

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CSO: 4009/1068

Physical Chemistry

INFLUENCE OF HEAT TREATMENT ON THE SUPERMOLECULAR STRUCTURES OF POLYETHYLENE-2.6 NAPHTHALATE

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese No 2, 1986 pp 58-62

[English abstract of article by Zhu Jumu [2612 1446 2606], et al.]

[Text] The crystallinity, the crystalline size and the interchain distance of amorphous have been calculated using the computer based multipeak resolution method to resolve the x-ray diffraction spectra of polyethylene-2.6 naphthalate (PEN-2.6) obtained at different heat treatment temperatures. The crystallinity calculated is consistent with those measured by the density method. By extrapolating the regressive curve of the density and the crystallinity to 100 percent and 0 percent, the same density as those presented in reference is obtained[1]. The relation curves of the crystallinity versus heat treatment temperature show that, when rising the heat treatment temperature, the crystallinity of PEN-2.6 increases, but the interchain distance of amorphous at lower temperature decreases. (Paper received 24 Nov 84.)

REFERENCES

- [1] Z. Mencik, C.A., 67(1967), 15849r.
- [2] 朱居木, 杜勇, 四川大学学报(自然科学版), 4(1985), 41.
- [3] L.E. Alexander, X-Ray Diffraction Methods in Polymer Science, John Wiley & Sons Inc 1969, 137-188.
- [4] F.W. Jones, Proc. Roy. Soc. 166A(1938), 16.
- [5] 中国科学技术大学高分子物理教研室, 高聚物的结构与性能, 科学出版社, 1983.

THE ROLE OF GRAPHITIZATION DURING SINTERING OF DIAMOND POWDER AT HIGH PRESSURE

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese No 2, 1986 pp 63-71

[English abstract of article by Li Boxun [2621 0130 8113], et al.]

[Text] Diamond powder was sintered with the aid of Ni-Ti alloy binder at 7.7 G pa and 1300-1700C. For the resulting sintered bodies the microstructure was observed, and the analysis of phase structure, phase composition was performed, the densification, wearing resistance and compressive strength were measured. The results showed that diamond graphitization is a key stage in sintering process, it plays an important role in the formation of bonding between diamond particles with alloy binder and the direct diamond-diamond bonding in sintered bodies. (Paper received 18 Feb 85.)

REFERENCES

- [1] M. Akaishi, H. kanda et al. J. Mater. Sci., 17 (1982), 193
- [2] 四川大学超硬材料研制組等, 四川省超硬材料經驗交流會資料, 1977
- [3] S. Naka, A. Tsuzuki et al, J. Mater Sci., 19 (1984), 259
- [4] В. П. уепелева, В. Г. Делеви, И. Я. Порошковая Металлургии, 1(1984), 66.

STUDIES OF THE ELECTRICAL PROPERTIES OF FeWB METAL GLASS AT HIGH TEMPERATURES

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 1, Jan 86 pp 50-55

[English abstract of article by Lu Qi [0712 2475], et al., of The Department of Physics]

[Text] The electrical properties of FeWB metal glass at high temperatures have not been reported so far. The electrical properties of $(\text{Fe}_{100-X}\text{W}_X)^{84.5}\text{B}_{15.5}$ ($X=2,4,6,8,10$) metal glass were studied with a self-designed measuring device. Measuring errors inherent in normal measurements were considerably reduced and the curve of relative change of electrical relaxation effect of metal glass was found to be the main cause of the deviation of the electric resistivity ρ (T) of metal glass from the linear relationship. The concept of "disorder sit" of scattering electrons in the glass was adopted to explain the drop off during the structural relaxation. Ziman's theory holds good only when the effect of structural relaxation was ignored. The Debye temperature θ_D of the material was not over 300K. (Paper received 24 Apr 84.)

REFERENCES

- [1] M.Sostarich, et al., Proc. Int. Conf. on Rapidly Quenched Metals 4th (Sendai, 1981), 1109
- [2] 詹文山, 等, Proc. Int. Conf. on Rapidly Quenched Metals 4th (Sendai, 1981), 1137
- [3] I.W.Donald, et al., Proc. Int. Conf. on Rapidly Quenched Metals 4th (Sendai, 1981), 597.
- [4] B.G.Lewis, et al., Proc. Int. Conf. on Rapidly Quenched Metals 3rd (Brighton, 1978), Vol. 2, 325
- [5] O.Dreirach, R.Evans, et al., J. Phys. F. (1972), 709
- [6] P.J.Cote, et al., Proc. Int. Conf. on Rapidly Quenched Metals 3rd (Brighton, 1978), Vol. 2, 62
- [7] D.J.Kim, et al., Phys. Rev., B15 (1977), 377

CYTOPROTECTIVE EFFECT OF PROSTAGLANDIN E₂ ON PANCREATIC ISLET β -CELL OF ALLOXAN-INDUCED DIABETIC RATS

Shanghai SHENGLI XUEBAO [ACTA PHYSIOLOGICA SINICA] in Chinese Vol 38, No 2, Apr 86 pp 191-201

[English abstract of article by Wang Jinlin [3076 6930 2651], et al., of Research Laboratory in Physiology of Digestion and Reproduction, Institute of Basic Medical Sciences, Beijing Medical University]

[Text] An experimental diabetes model was produced by subcutaneous injection of alloxan monohydrate in a dose of 200 mg/kg. Prostaglandin E₂ (PGE₂) administered intraperitoneally 15 minutes prior to alloxan was able to decrease the incidence of alloxan-induced diabetes from 75 percent of the control to 12.5 percent and to decrease the mean average of plasma glucose concentration from 498.0 $\pm$ 86.6 mg% of the control to 141.9 $\pm$ 30.5 mg% at 72 hours after the injection of alloxan.

The protective effect of PGE₂ was dose dependent. The oral glucose tolerance test at 120 hours after the injection of alloxan showed that the curves were markedly reduced in the rats pretreated with PGE₂. The microscopic section of the pancreatic islets of the rats that were pretreated with PGE₂ showed that the concentration of secretory granules in β cells was markedly increased as compared to the alloxan-induced diabetic rats. The result indicates that the acute damage of β cells caused by alloxan was milder in the rats pretreated with PGE₂. From the functional as well as morphological investigation, we suggest that PGE₂ might have a cyt protective effect on the β cells of the pancreatic islets in rats. (Paper received 13 Aug 84, finalized 14 Nov 84.)

REFERENCES

- [1] Robert, A. (1979). Cytoprotection by prostaglandins. *Gastroenterology*, **77**, 761-767.
- [2] Stachura, J., Tarnawski, A., Ivey, K. J., Mach, T., Bogdal, T., Szczudrawa, J. and Klimczyk, B. (1981). Prostaglandin protection of CCl₄-induced liver cell necrosis in the rat. *Gastroenterology*, **81**, 211-217.
- [3] Manafe, T. (1980). Protective effect of PGE₂ on diet induced acute pancreatitis in mice. *Gastroenterology*, **78**, 777-781.
- [4] 周序开(1982). 血浆(及全血)葡萄糖测定—葡萄糖氧化酶法的探讨. 中华医学检验杂志, **5**, 56-60.
- [5] Lazarus, S. S., Barden, H. and Bradshaw, M. (1962). Pancreatic beta cells and alloxan toxicity. *Archives of Pathology*, **73**, 210-222.
- [6] Gomori, G. (1950). Aldehyde fuchsin, a new stain for elastic tissue. *Am. J. Clin. Pathol.*, **20**, 665-666.
- [7] Robert, A. (1981). Current history of cytoprotection. *Prostaglandins*, **21**, (suppl.) 89-93.
- [8] 王志均(1984). 胃肠道的细胞保护. 生理科学进展, **13**(1), 5-10.
- [9] Rumini, A. A., Arcangeli, M. A. and Cahill, D. F. (1975). Studies of the alloxan toxicity on the beta cell. *Diabetes*, **24**, 516-522.
- [10] Weaver, D. C., McDaniel, M. L. and Lacy, P. E. (1978). Alloxan uptake by isolated rat islets of Langerhans. *Endocrinology*, **102**, 1847-1855.
- [11] Robertson, R. P., Gavareski, P. J., Porter, D. Jr. and Bierman, E. L. (1974). Inhibition of in vivo insulin secretion by prostaglandin E₁. *J. Clin. Invest.*, **54**, 310-315.
- [12] Brenner, R., Vargos-Cordon, M. and Lebowitz, H. E. (1968). Tranycypromine: a potent insulin secretagogue and hypoglycemia agent. *Diabetes*, **17**, 617-624.
- [13] Pek, S., Tai Tun-yuan and Elster, A. (1978). Stimulatory effect of prostaglandin E₁, E₂ and F₂ on glucagon and insulin release in vitro. *Diabetes*, **27**, 801-809.
- [14] Scheynius, A. and Talyedal, I. B. (1971). On the mechanism of glucose protection against alloxan diabetes. *Diabetologia*, **7**, 252-255.

RESPONSES OF HYPOTHALAMIC PARAVENTRICULAR NEURONS TO ELECTRICAL STIMULATION OF MIDBRAIN CENTRAL GRAY (CG) AND LEMNISCUS MEDIALIS (LM) IN THE RAT

Shanghai SHENGLI XUEBAO [ACTA PHYSIOLOGICA SINICA] in Chinese Vol 38, No 2, Apr 86 pp 210-215

[English abstract of article by Xing Baoren [6717 1405 0088], et al., of Department of Physiology, Second Military Medical College, Shanghai]

[Text] The experiments were performed on 28 rats immobilized with Flaxedil. Unit discharge of PVH neurons was recorded by glass microelectrode extracellularly. CG and LM in midbrain were stimulated with bipolar electrode respectively.

The activity of neurons in the PVH and its responses to brain stimulation were observed. The main results are as follows: After CG stimulation, 4 units showed antidromic response, 47 units showed orthodromic responses with different types: Type I was responsive to single stimulus, while type II was responsive only to a train of stimuli. No response to LM stimulation was observed.

These results suggest that there are two-way connections between PVH and CG, but no connection between PVH and LM could be demonstrated electrophysiologically. (Paper received 10 Dec 84, finalized 10 Apr 85.)

REFERENCES

- [1] Sawchenko, P. E. and Swanson, L. W. (1983). The organization and biochemical specificity of afferent projections to the paraventricular and supraoptic nuclei. In Cross, B. A. and Leng, G.: The neurohypophysis: structure, function and control. p19-27, Elsevier Amsterdam, New York.
- [2] Morris, J. F.: Organization of neural inputs to the supraoptic and paraventricular nuclei: Anatomical aspects. *ibid*, p3-8.
- [3] Sofroniew, M. V.: Morphology of vasopressin and oxytocin neurons and their central and vascular projection. *ibid*, p101-114.
- [4] Swanson, L. W., Sawchenko, P. E. Rivier L., Vale W. W. (1983). Organization of ovine corticotropin-releasing factor immunoreactive cells and fibers in the rat brain: An immunohistochemical study. *Neuroendocrinology*, 36, 3 p165-186.
- [5] Pittman Q. J. Blume H. W. and Renaud, L. P. (1981). Connections of the hypothalamic paraventricular nucleus with the neurohypophysis, median eminence, amygdala, lateral septum and midbrain periaqueductal gray: An electrophysiological study in the rat. *Brain Res.*, 215, 15-28.
- [6] Tribollet E. A and Dreifuss, J. J. (1981). Localization of neurons projecting to the hypothalamic paraventricular nucleus area of the rat: a horseradish peroxidase study. *Neuroscience*, 6, 1315-1328.
- [7] Aulsebrook L. H. and Roland, R. C. (1969). Central inhibition of oxytocin release. *Am. J. Physiol.*, 216, 4830-4842.
- [8] Vincent J. D., Pominic Poulain, D. A. and Arnauld E. (1980). Electrophysiology of magnocellular neuroendocrine cells. In Barder J. L. and Smitu T. G. Jr: The role of peptides in neuronal function. pp230-272. Marcel Dekker Inc., New York and Basel.
- [9] Pellegrino, L. T., Pellegrino, A. S. and Cushman, A. J. (1979). A stereotaxic atlas of the brain, Plenum Press.
- [10] 邢宝仁、夏金辉、陈宜张 (1984). 下丘脑室旁核-下丘脑前区神经元对电刺激丘脑束旁核的逆行反应和顺行反应. *生理学报*, 36(6), 595-600.
- [11] 宋朝佑等 (1981). 侧脑室注射后叶素、缩宫素及加压素对叫反应的影响. *生理学报*, 33(3), 283-242.
- [12] 宋朝佑等 (1984). 侧脑室注射缩宫素、加压素及后叶素对清醒猫叫反应的影响. *生理学报*, 36(4), 336-341.
- [13] 王璞石等 (1982). 下丘脑室旁核传入神经的起源. *解剖学通报*, 9.

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FILAMENTATION INSTABILITY OF WHISTLER WAVE IN THE MAGNETOSPHERE

Beijing KONGJIAN KEXUE XUEBAO [CHINESE JOURNAL OF SPACE SCIENCE] in Chinese
Vol 6, No 1, Jan 86 pp 23-31

[English abstract of article by Wang Yuandian [3769 0337 3013] of Institute
of Space Physics, Academia Sinica]

[Text] The filamentation instability of whistler waves in the magnetosphere is analyzed in this paper, and the growth rate is calculated. For propagation path $L \approx 4$ and electric field of the wave 1 mV/m, the maximum growth rate is about 0.13/1000 km, the corresponding perpendicular wave length is about 400 km (near the equator region). It is also pointed out that the filamentation instability discussed here may offer a nonlinear mechanism for the multipath propagation of whistlers.

NUMERICAL EXAMINATION OF AKASOFU'S ENERGY COUPLING FUNCTION

Beijing KONGJIAN KEXUE XUEBAO [CHINESE JOURNAL OF SPACE SCIENCE] in Chinese
Vol 6, No 1, Jan 86 pp 32-41

[English abstract of article by Xu Wenyao [1776 2429 5069] and Shi Enqi [1597 1869 1142] of Institute of Geophysics, Academia Sinica]

[Text] Based on the general formula of the energy transfer rate from the solar wind into the magnetosphere, the coupling mechanism of MHD flow is examined by using solar wind data for a period of 34 days. It is shown that MHD flow mechanism is valid when $B_z < 0$ (or IMF is southward). In this case the energy transfer rate can be expressed by $P = C B_T^{2/3} V^{5/3} n^{1/3} \sin^4(\theta/2)$. This is different from Akasofu's coupling function, but in good agreement with Murayama & Hakamada, Svalgaard, Murayama, and Holzer & Slavin. The factors influencing the calculations of coupling function are also discussed.

SELF-EXCITATION EFFECT OF SCATTERING OF ELECTROMAGNETIC RADIATION IN A STRONG MAGNETIC FIELD

Beijing KONGJIAN KEXUE XUEBAO [CHINESE JOURNAL OF SPACE SCIENCE] in Chinese
Vol 6, No 1, Jan 86 pp 42-50

[English abstract of article by Liu Xuwei [0491 4371 0251] of Purple Mountain Observatory, Academia Sinica]

[Text] In light of the solution of electron motion equation in a magnetic field, the electron scattering in response to the incident electromagnetic wave of frequency ω_i includes the part whose frequency is the same as the cyclotron one besides that of frequency ω_i . This effect can be called the self-excitation and, except the highfrequency limit, has a considerable influence upon the cross section. In this paper, the modified cross sections of classical non-relativistic electron in the case of both a single electron and cold plasma are given. The spectrum distribution of electron scattering is discussed, and the Thomson absorption coefficients of magnetized thermal equilibrium plasma are obtained for some typical cases. It is also pointed out that the result here can be applied for many astrophysical aspects such as the spectrum formation of X-ray pulsars.

DYNAMICAL THEORY OF MULTI-FUNCTION DRY-TUNED ACCELEROMETER/GYRO

Beijing KONGJIAN KEXUE XUEBAO [CHINESE JOURNAL OF SPACE SCIENCE] in Chinese
Vol 6, No 1, Jan 86 pp 75-80

[English abstract of article by Wang Huinan [3769 1920 0589] of Nanjing Aeronautical Institute]

[Text] In contrast to symmetric rotor of Dry-tuned GYRO (DTG), the rotor of Dry-tuned accelerometer/GYRO (DTAG) has different transverse moments of inertia and a proper rotor pendulosity. DTG can be improved to DTAG. This instrument provides measurements of angular rate about two axes and linear accelerations along two axes. The study of DTAG is a significant effect on the development of Inertia Navigation System.

This paper presents the dynamical equations of DTAG. Under the condition of multi-frequency vibration, the stationary solution is computed according to the analyses of the dynamics. The feasibility of dry-tuned sensor technology for mechanizing an inertia grade four-axes multi-function sensor is demonstrated.

This paper also presents the condition of eliminating error torques resulting from angular vibration inputs of double spin frequency of the driving shaft. This condition is obtained by way of simple construction of single gimbal GYRO.

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China Report

SCIENCE AND TECHNOLOGY



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NATIONAL DEVELOPMENTS

GROUP OFFICIALLY FORMED IN 1985 FOR CHARACTER CODING STANDARD

Beijing ZHONGGUO BIAOZHUNHUA [CHINA STANDARDIZATION] in Chinese No 8, Aug 85 p 1

[Jointly issued notice by the State Council Office of the Leading Group for Promotion of Electronics, the State Science and Technology Commission, and the State Bureau of Standards: "Circular Regarding Developing Technical Appraisals of Chinese Character Input Coding"]

[Text] The State Council Office of the Leading Group for Promotion of Electronics, the State Science and Technology Commission, and the State Bureau of Standards recently joined to issue the "Circular Regarding Developing Technical Appraisals of Chinese Character Input Coding" in hope that all relevant areas would take heed and support it.

The "Circular" points out that Chinese characters make up the working language of this country, and proper resolution of Chinese character data processing technologies is a key to the universal application of computers in China. In recent years, there has been much work done domestically on Chinese character input coding, many methods have been proposed, there have been many different plans for coding, and the optimization of these plans has become a problem in urgent need of resolution for the dissemination and application of data processing technologies. To enhance leadership and to do the work well, it is intended that the State Bureau of Standards take the lead and join with the China Chinese Language Information Research Conference to comprise a "Chinese Character Input Plan Evaluation Group" (the working group to depend upon the Institute of Information Categorization and Coding of the State Bureau of Standards).

The "Circular" states that the responsibilities of the working group will be: to assume responsibility for the overall plan and organization for the optimization of Chinese character input coding plans, and to progressively develop relevant standardization; to rely upon societies, to organize specialists to unify evaluation standards, and to integrate evaluation activities in organizing and coordinating relevant units in optimizing a feasible Chinese character input coding plan that suits our national situation, the results to be reported to the state for approval; and to be responsible for the collection and management of domestic Chinese character input plans.

The "Circular" requires that to review experiences and keep the work moving, a national appraisal activity is scheduled to be organized in October of this year [1985]. Chinese character input coding plans developed by departments, regions, or individuals may be volunteered or recommended for participation, for which request support from relevant sources. The optimized plan to be put forward during appraisal will be recommended for inclusion in the "National Exhibit of Computer Applications" to be held in 1986, for which relevant areas are requested to prepare well.

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CSO: 4008/1072

NATIONAL DEVELOPMENTS

CHINESE CHARACTER TYPE MATRIX STANDARDS ISSUED

Beijing ZHONGGUO BIAOZHUNHUA [CHINA STANDARDIZATION] in Chinese No 8, Aug 85 pp 1-2

[Text] The State Bureau of Standards held a news conference 21 May [1985] in Beijing regarding Chinese written language information processing standards. At the conference, State Bureau of Standards Deputy Director Zhong Ming [6988 2494] issued two standards for Chinese written language information handling, the GB5007.1-2-85 "Character Matrix Sets and Data Sets for Information Exchange Using a 24 X 24 Matrix" and the GB5199.1-2-85 "Character Matrix Sets and Data Sets for Information Exchange Using a 15 X 16 Matrix." These two national standards began implementation on 1 June 1985 and 1 October 1985, respectively. At the same time, the State Bureau of Standards formally authorized the Department of Information at the Yanshan Computer Applications Research Center to be responsible for providing floppy disks and fixed-mask ROM (MASKROM) that have the complete dot matrix character matrix data sets, together with indexes, which will guarantee the accurate implementation of standards.

With the rapid development and application of our computer technology, many industrial and applications departments are in urgent need of a set of high quality, standardized Chinese character type matrices and type matrix data. Based on the requirements of national tasking regarding the scientific and technical problem of Chinese character type matrix sets and data sets, by recommendation of the Ministry of the Electronics Industry, units of the Information Department of the Yanshan Computer Applications Research Center and the Shanghai Institute of Printing Technology jointly developed standards for "24 X 24" and "15 X 16" dot matrices, and with the close cooperation of specialists and 2 years of thorough study and repeated experience, that task has been outstandingly accomplished. These two standards meet relevant regulations regarding national standards for the exchange coding of our Chinese characters; the two sets of type matrices use the publishing Song typeface scheme, the character shape dot matrices are accurate, the core is stable, strokes are fluid, and they suit relevant national scales for the written language. When comparing these character shapes with similar ones both in this country and abroad, the former are of a higher standard. Because of uniform writing of the standard and assigned provision of the standard product, not only will this lay the technical foundation for the unification of Chinese character output shapes in this country, for the development of

Chinese character optical recognition technologies, and the production of Chinese character terminals, but will also bring major economic and social results to the development of information technology in this country.

Finally, Deputy Director Zhong Ming made a concise policy explanation regarding the problem of protecting international cooperation in standardizing scientific and technical projects and protecting standardization rights. Based on the spirit of the "Resolution by the CPC Central Committee Regarding Restructuring of the Science and Technology System," the State Bureau of Standards intends to gradually develop international technical cooperation in information technology, including development of the standardization of science and technology projects such as Chinese character information technologies, and will as well have test sites. Particular affairs concerning the open door policy and cooperation with national standardization of science and technology will be the responsibility of the China Association of Standardization. He pointed out that if foreign companies want to directly use major Chinese research achievements in technology standardization, they must respect our rights. In addition, he also announced that based on the regulations in Item 3 of Section 2 of the "Standardized Inspection and Control Methods for the Import of Technology and Equipment" as jointly issued by the State Bureau of Standards, the State Planning Commission, the State Economics Commission, the State Science and Technology Commission, and the Ministry of Foreign Economic Relations and Trade, the State Bureau of Standards will join with relevant departments to undertake standardized inspections of computer equipment imported in lots in order to strengthen the uniform management of the technical standardization of information processing.

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CSO: 4008/1072

NATIONAL DEVELOPMENTS

STANDARDS PLANNING MANAGEMENT SOFTWARE DESCRIBED

Beijing ZHONGGUO BIAOZHUNHUA [CHINA STANDARDIZATION] in Chinese No 8, Aug 85 pp 24-25

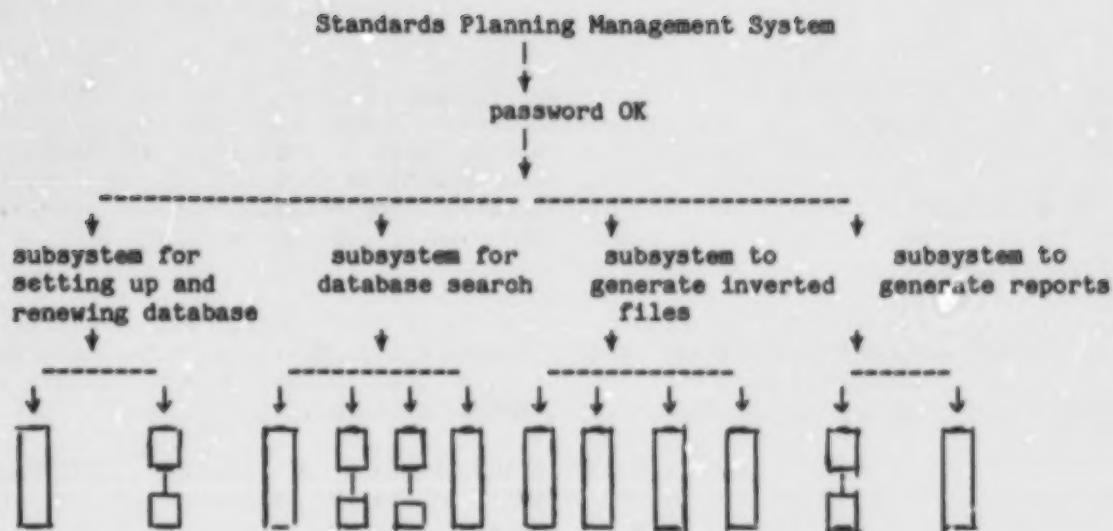
[Article by Zhan Yinghao [6124 5391 3185]: "A Computer Management System for Standards Planning"]

[Text] At present, to suit development of the national economy, many standards management departments have produced plans for formulation and revision of standards based on actual conditions. Because all departments are responsible for so many different standards and there are so many and they cover so much area, it is very troublesome to manually search out from planning how many of a certain kind of standard ought to be worked out in a given year from planning. Consequently, since computers have the capacity for high speed processing of data, if they are used to accomplish this work, then that will be very convenient and quick.

After a computer retrieval system was established for standards documents, we began a computer management system for standards planning in early 1985, which put automation of standards planning and management into effect in a timely manner.

I. The Overall Structure of the Computer Management System for Standards Planning

The standards planning computer management system is composed of the following four independent subsystems (see diagram):



Overall Diagram of Standards Planning Management

Each subsystem is composed of mutually independent function modules, and these function modules are in turn comprised of several related or parallel subsystems.

1. Subsystem to establish and renew the database.

Taking practical use into consideration, database records are composed of a number, name of standard, number of document category for the standard, date of drafting, date of approval, level of the standard, number of standards, drafting unit, and managing unit, and each record has a fixed length of 256 bytes. The main file of the database is the set of these various records.

In the subsystem to establish and renew the database, a series of operations may be performed on the main file of the database, such as setting up, revising, inserting, and deleting.

2. Subsystem for database searching.

Because the management system for standards planning caters to standardization management personnel, to free these people from a lot of retrieval and statistics work, five different paths have been established in the database retrieval subsystem: retrieval and statistics by category, retrieval and statistics by date of drafting, retrieval and statistics by date of approval, retrieval and statistics by drafting unit, and retrieval and statistics by combinations.

a. The path of retrieval and statistics by category. The categorizing methods we have used are the "Methods for Categorizing China's Standards Documents (provisional)", which in the future is certain to be well known by

standards management personnel in this country, and which will then have greater practical use.

b. The path of linked retrieval and statistics. This path does an arbitrary logical combination of the five data items: standards document category number, drafting unit, managing department, date of drafting, and date of approval, and the computer can find standards plans that satisfy the logical expression from the main file of the database. For example, it can retrieve certain kinds of standards through this path by the particular year and drafting unit.

c. The path of retrieval and statistics by date of drafting. This path retrieves standards by date drafting began through drafting date inverted files and the database main file, which is of great convenience to standards management departments when formulating annual planning.

d. The path of retrieval and statistics by date of approval. Through retrieval of date of drafting inverted files and the database main file, management personnel can be aware of standards sent for approval each year and their numbers, which consequently allows for approval according to a rational arrangement by date.

e. The path of retrieval and statistics by drafting unit. Through a computer search of drafting unit inverted files and the database main file, this allows people to know the standards drafted by a particular unit and their numbers.

The five retrieval paths each set up its own counter so that all can compile the numbers of the standards plans that satisfy retrieval requirements.

3. Subsystem for generation of inverted files.

There are four inverted files in the standards planning management system. They are categorical inverted files, drafting unit inverted files, drafting date inverted files, and approval date inverted files. These inverted files are automatically generated as the main file of the database is set up, they are the core files for retrieval, and it is they through which rapid retrieval according to the four modes of category, drafting unit, drafting date, and approval date is realized.

4. Subsystem for report generation.

To satisfy different management requirements, the standards planning management system includes a report generation subsystem. In reports from the report generation subsystem, the report formats may be arbitrarily changed, and management personnel may interactively define report output formats to their own satisfaction. Standards plans that satisfy retrieval requirements may be output on a printer or a terminal.

II. Software Design Characteristics of the Standards Planning Management System

1. Using an advanced database management system (DBMS).

Having used a database management system to write the standards planning management system software allows the data to be least redundant, so that it can serve in many applications in the optimal format: data may be shared; data storage is independent of using its application program, that is, data is independent.

2. Quick response time.

Because the advanced techniques of B+ tree search organizational structure and inverted files has been used in the standards planning management system software, this allows the computer to access any file in the database within 2 seconds.

3. Varied retrieval and statistics paths.

The standards planning management system software sets up the five retrieval and statistics paths: standards document categories, standards drafting units, standards drafted year, standards approval year, and combinations. It is especially the semi-programming techniques in the combination searches of macro substitutions, reverse Polish exchange, and intermediary code generation that allows the user to undertake various logical combinations (AND, OR, NOT) of the five data items: standards document category, standards drafting unit, standards management unit, standards drafted year, and standards approval year. The number of logical expressions that can be formed is given in:

$$C^1 + 3C^2 + 3^2C^3 + 3^3C^4 + 3^4C^5 = 5 + 30 + 90 + 135 + 81 = 341$$

That is, there are 341 different ways to search the main file of the database using the combination retrieval and statistics path, and it may be said that with so many changes, this will be very convenient for various kinds of users.

4. User defined report formats.

Because the standards planning management system software has used a database management system (DBMS), this basically solves the deficiency in file management systems whereby data cannot be interchanged, for the software can combine various different data files for report output, and the user can define the report output format that he needs in the report generation subsystem. The computer will then print out reports based on this format.

III. Conclusions

Currently, the standards planning management system software is running regularly on a Cromemco computer. Because the currently domestically popular Great Wall 0520, IBM-PC/XT, and compatibles are all available with a database management system similar to that of the Cromemco, the standards planning management system software can be transferred to the IBM-PC/XT and compatibles

with nearly no changes. This gives the software a strong hardware adaptability.

The standards planning management system has just been established, there are many areas that need more work, and so we will continue to be diligent so that we can make new contributions to modernizing our standardization work.

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CSO: 4008/1072

COMPUTER USE IN CALCULATING POWER SUPPLY NETWORK LOSSES

Xian DIANLI DIANZI JISHU [POWER ELECTRONICS] in Chinese No 1, 1 Feb 86 pp 44-48

[Article by Shen Qingyue [3088 1987 6460]]

[Text] Computers are increasingly used today in engineering calculations, and because of their speed, large memory capacity, precision, and the availability of external recording devices, they have greatly increased the efficiency with which engineering calculations can be performed. In particular, the availability of pocket calculators and microcomputers has opened up new areas in applied computing.

Computers are widely employed in electric power systems, and the calculation of network losses is only one of many possible applications. However, it is an important one because power networks are widely used in both urban and rural areas. Since the calculations are both useful and flexible, we will illustrate them here by discussing a program for calculating network losses using a PC-1500 pocket calculator. The PC-1500 has an 8-bit central processing unit and comes with 16K of firmware for supporting the BASIC language. The internal storage can be increased to 26K, although one 8K memory module suffices for our application. The computer has a one-line liquid crystal display and cassette for external storage. The microprinter available for the PC-1500 is of particular note—it is four-directional, prints in four colors, and has two operating modes; moreover, it can handle Chinese-language databases and produce output in Chinese characters, and it is equipped with internal memory which is reserved for printing applications. Only a CE-158 interface cable is needed to permit the printer to communicate with the microcomputer. The PC-1500 is well suited for calculating network losses when the total number of calculations is not too great and a high degree of flexibility is desired.

1. Algorithm for Calculating Network Losses

There are two methods that are widely used to calculate electric power losses in networks—one uses the average value of the electric current, while the other (current-squared) method requires sampling the current at regular intervals and forming the sum of the squares. Either method is suitable for computer implementation, and the choice depends on the properties of the computer and the characteristics of the power grid.

Before the calculations can be carried out, initial data must be input to the computer. These data should be measured as accurately as possible, with sources of human error eliminated; however, the meters themselves have a finite error which must also be taken into account. In the current-squared method, the parameters characterizing the environment do not have to be supplemented by additional correction parameters, and neither voltage values nor electric meters are required. Although the hourly current readings for a given day must be processed to give a representative daily current and derive a network loss figure valid for that day, the required calculations are easily carried out on a computer.

In the time-squared method, the network current is calculated in terms of certain parameters K_1 called the current drop ratios. Since the currents in the various parts of the network depend on user demand, which is easily measured, the total current withdrawn from successive stages of the network can be found and the corresponding drops K_1 calculated. Since the power is proportional to I^2R , the equivalent resistance for stage 1 of the circuit from which a known current is withdrawn is given by multiplying the resistance R_1 of the section by K_1^2 . The output resistance is the sum of the equivalent resistances for each stage.

In addition to the losses in the wires, networks also suffer from ac power losses and from losses in power meters and lines connecting the grid to the users. The ac losses are calculated in terms of the nominal parameter values but can be corrected (if the grid and meter voltages differ significantly) by taking the ratio of the grid and meter voltages; the other losses can be calculated by taking appropriate ratios of the total electricity passing through the various stages of the network.

The detailed steps for calculating the daily losses are as follows:

- (1) First, calculate the equivalent resistance $R_1' = R_1 K_1^2$ of the 1-th stage; here R_1 is the resistance of stage 1 and

$$K_1 = \frac{A_1 + A_{1+1} + \dots + A_n}{A_1 + A_2 + \dots + A_1 + \dots + A_n}$$

where A_1 is the time-integrated current (charge) flowing through stage 1.

- (2) The output resistance is then given by the sum

$$R = R_1' + R_2' + \dots + R_n' = \sum_{i=1}^n R_i'$$

where n is the number of stages in the network.

- (3) One then computes the sum of the squares

$$I = I_1^2 + I_2^2 + \dots + I_n^2 = \sum_{i=1}^n I_i^2$$

of the daily current readings; here I_1 is the output current sampled at time $t = 1$ hours.

(4) The loss rate in the network wires is then given by

$$\Delta A_d \text{ percent} = \frac{I \cdot 3R \cdot 10^{-3}}{A_{ds}} \times 100$$

where A_{ds} is the total electricity supplied per day.

(5) The power loss in the wires is then

$$\Delta A_L = A_s \cdot \Delta A \text{ percent} \cdot (P_{ma}/P_{da}) \cdot K_R/100$$

where A_s is the average electricity delivered per month; P_{ma} and P_{da} are the monthly and daily average loads; T_m and T_d are the number of hours during the month or day when electricity is supplied; the factor K_R corrects for ambient temperature (see Table 1).

Table 1.

Type	Quarter	1	2	3	4	Yearly total
Loss in network wires		0.95	1.05	1.1	1.0	1.05
Loss in transformer windings		1.0	1.10	1.15	1.05	1.1

(6) The equivalent resistance for the ac losses is given by

$$R_T = P_T \cdot 10^3 / (S \cdot 0.0577)^2$$

$$P_T = P_1 + P_2 + \dots + P_n = \sum_{i=1}^n P_i$$

$$S = S_1 + S_2 + \dots + S_n = \sum_{i=1}^n S_i$$

where P_i is the power loss in the transformer (copper loss) for stage i of the network, and S_i is the corresponding rated capacitance of the transformer.

(7) The power delivered at low voltage to the user is described by

$$K_D = \frac{A_1 + A_2 + \dots + A_n - A_{HV}}{A_1 + A_2 + \dots + A_n}$$

where A_{HV} is the electricity supplied at high voltage.

(8) The copper losses in the transformers are given by the product

$$\Delta A_C = (I \cdot K_D \cdot 10^{-3} \cdot R_T \cdot (P_{ma}/P_{da})^2 \cdot (T_m/T_d) \cdot K_R$$

(9) The losses in the transformer cores are

$$\Delta A_I = B \cdot T_m$$

$$B = B_1 + B_2 + \dots + B_n = \sum_{i=1}^n B_i$$

where B_i is the rated core loss for transformer i .

(10) The remaining losses caused by connecting the users to the grid and the losses from other sources are given by

$$\Delta A_u = A_{ms} \cdot K_D \cdot 1 \text{ percent}$$

(11) The total network loss is given by the sum

$$\Delta A = \Delta A_L + \Delta A_C + \Delta A_I + \Delta A_u$$

2. Program

The program for calculating the losses breaks into two main parts which compute the wire losses and the transformer, user connection, and other losses, respectively. The losses in the network wires comprise a large fraction of the total losses and the principal step in their calculation is to find the equivalent resistances R_1' . In accordance with the structure of the network, this portion of the program is divided into two parts which describe the main power lines and their branches, respectively.

The initial values needed in the calculations are input interactively by the user. However, since this method makes it impossible to correct input errors, the program also lists the values. If inspection reveals an error, the incorrect value(s) can be changed. The data are arranged as matrices; each matrix corresponding to a specific physical parameter, and each matrix element gives the value of the parameter for a specific stage of the network. The data used to calculate the transformer losses are organized in the same way, so that the calculations primarily involve matrix operations.

The computed results can be output in tabular form or schematically, in which the network is represented by a sequence of nodes with the equivalent resistances displayed. After the program has terminated, the results can be output in either of these two forms as many times as desired. The tables are provided with Chinese-language captions to make them easier to interpret. The Chinese characters are printed out in graphics mode; each time a character is to be printed, a printer subroutine is called which outputs the numeric codes corresponding to the dot pattern stored in graphics memory for the character.

3. A flowchart of the program is presented. We will illustrate it by going through a specific example of which we calculate the network losses for a farming village on the outskirts of a city. Because the primary network contains some branch lines which are little-used (or else are so short that they have little influence on the total losses), the network model is first simplified by incorporating these branches into others; the branches and the corresponding parameters of the resulting network are shown in Figure 2.

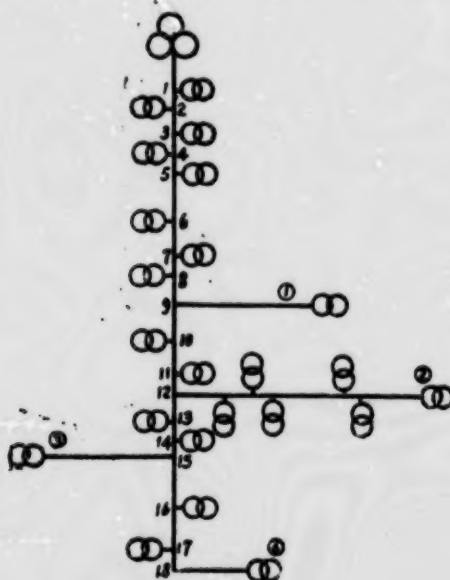


Figure 2.

Table 2.

Node	kwh	Resistance	Node	kwh	Resistance
1	4,608	0.63	Branch 1:		
2	7,693	0.11	1	38,828	2
3	600	0.37	Branch 2:		
4	7,266	0.2	1	6,879	0.77
5	3,560	0.2	2	3,096	0.36
6	12,630	0.6	3	23,419	1.28
7	18,355	0.38	4	22,023	0.42
8	10,275	0.1	5	9,754	0.18
9	38,828	0.3	6	50,733	1.28
10	18,896	0.31	Branch 3:		
11	3,500	0.37	1	57,295	2.4
12	115,904	0.16	Branch 4:		
13	6,895	0.26	1	55,298	1.7
14	7,154	0.11			
15	57,295	0.1			
16	1,155	0.61			
17	9,543	0.3			
18	55,298	0.07			

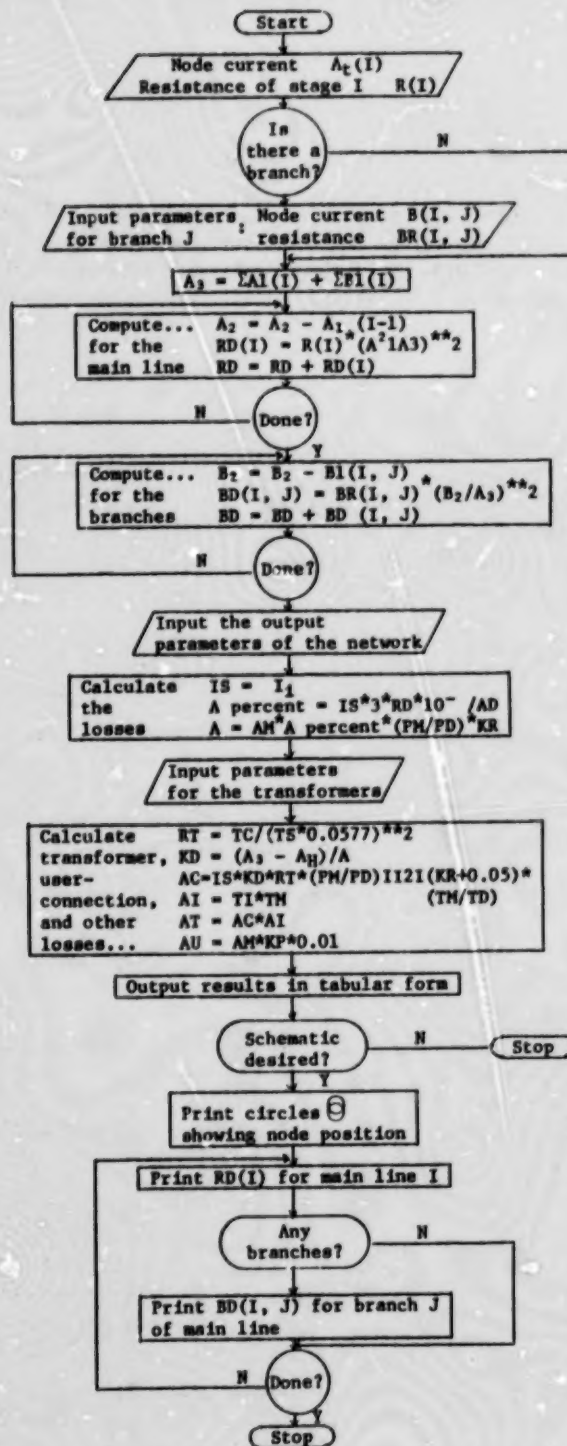


Figure 1.

The hourly output currents are listed in Table 3, while Table 4 lists the transformer characteristics (the capacitance, the number of step-down transformers, and the type of losses). The parameters listed in the three tables must all be input to the computer, which prompts the operator with a question mark "?" after which the value is entered. After each phase of data entry, the values are displayed on the screen for review and possible correction (to correct a value one presses Y on the keyboard; otherwise, the program continues).

Once all the data have been entered the calculations begin, and after a while the printer outputs the results as a table of numbers. If the operator wants a simplified schematic of the network with the calculated currents and equivalent resistances displayed on it, the Y key is pressed in response to a prompt and a multicolored schematic is printed out. To print out data in tabular form one types the instruction GOTO 500, while to get a simplified schematic one types GOTO 620 (there is no need to run the program twice). The results are displayed as shown in Table 5.

Table 3. Hourly Currents for a 24 Hour Period

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Current	10	8	25	27	52	30	54	55	58	65	55	65	62	65	60	72	68	63	48	45	38	30	30	30

Daily supply (kwh)	No of hours electricity is supplied	Monthly supply (kwh)	No of hours per month electricity is supplied	No of kwh supplied on high voltage lines
16,800	24	423,200	673	74,722

Table 4.

Type of losses	Capacitance kVA	20	30	50
Number of step down transformers		20	14	27
Nominal core losses, kw		0.21	0.3	0.44
Copper losses in the windings, kw		0.62	0.85	1.33

Table 5.

Node	kwh	Resistance	Equivalent resistance
1	4,608	0.68	0.68
2	7,693	0.11	0.11
3	600	0.37	0.35
4	7,266	0.2	0.19
5	3,560	0.2	0.13

[continued]

[Continuation of Table 5]

Node	kwh	Resistance	Equivalent resistance
6	12,630	0.6	0.53
7	18,355	0.38	0.31
8	10,275	0.1	0.07
9	38,828	0.3	0.21
10	18,896	0.31	0.16
11	3,500	0.37	0.17
12	115,904	0.16	0.07
13	6,895	0.26	0.03
14	7,154	0.11	0.01
15	57,295	0.1	0.01
16	1,155	0.61	0.02
17	9,543	0.3	0.01
18	55,298	0.07	0

Branch 1:

1	38,828	2	0.02
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Branch 2:

1	6,879	0.77	0.07
2	3,096	0.36	0.03
3	23,419	1.28	0.1
4	22,023	0.42	0.02
5	9,754	0.18	0
6	50,733	1.28	0.02

Branch 3:

1	57,295	2.4	0.05
---	--------	-----	------

Branch 4:

1	55,298	1.7	0.04
---	--------	-----	------

Equivalent resistance of the wires

3.468

I1 + .. + I24 = 65,976

T day = 24

T month = 678

A day = 16,800

A month = 423,200

AL day percent = 4.09

P day = 700

P month = 624.19

KR = 1.1

Wire losses 16,959.7

RD t = 3.841

A high = 74,722

AA to = 5,256.478169

AA to = 13,749.84

Transformer losses 19,006.32

Connection wires 3,398.64

Total losses 39,364.6

1

12617/9365
CSO: 4008/1048

PROBLEMS APPLYING DATABASE TECHNIQUE TO TDC SYSTEM

Xian GONGYE YIBIAO YU ZIDONGHUA ZHUANGZHI [INDUSTRIAL INSTRUMENTATION AND AUTOMATION] in Chinese No 2, 5 Apr 86 pp 13-17

[Article by Su Yongle [5685 3057 2867], Xian Institute of Industrial Automation Instrumentation: "A Preliminary Study of Two Problems of Applying a Database Technique to a TDC System"]

[Text] Abstract: Database techniques are currently applied in China mainly in information management and enterprise management. Yet, in terms of development, application of database techniques in TDC systems is undoubtedly an important area. This paper explores how to resolve two problems which crop up when applying database techniques in TDC systems, viz., realtime and operating language design.

The Function of Databases

The primary role of a database as part of a TDC system, is first of all to organize different control systems by different processes through database operation; next, through the process parameters, system parameters and related information in the collector control system it conversely acts in the control system to express the controls of the actual object.

The logic relationship of the control system and the database are as illustrated in Figure 1.



Figure 1

Key:

- a. Query and operation
- b. Database
- c. Control system
- d. Control action

On Realtime Problems

In TDC systems, the high realtime demands are one of the most prominent problems. Thus, resolving the realtime problem is a key problem for database technique application in TDC systems. This problem will be discussed below:

1. Process interface

Ordinarily, the logic structure of a database is as illustrated in Figure 2. Using this structure, the user only communicates with

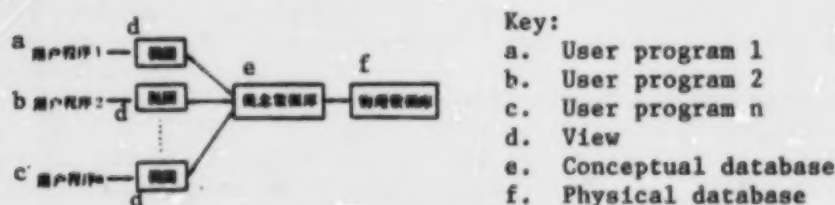


Figure 2

the view and does not communicate directly with the physical database. Thus, each operations command sent from the user's terminal is relayed through several levels to the physical database and then returns from the physical database to the user's terminal, and the time required is rather long. Currently, the computers used in industrial process control are primarily mini-computers and microcomputers and it is very difficult to obtain satisfactory realtime response using this type of database system structure.

To solve this problem, we introduced the concept of the process interface. The process interface is a mechanism through which high demand realtime operation commands and queries are communicated directly with the physical database and do not go through conceptual database conversion. In addition, communication between the physical database and the process control system is also carried out through the process interface so that the process control system is not directly linked to the conceptual database. Changes in process parameters in the control system are frequent, and while these changes cause frequent changes in the physical database, linking the control system and the physical database directly through the process interface without requiring conversion through the conceptual database, can save a great deal of time in order to guarantee realtime.

According to this conception, processing of some operational commands and queries with realtime demands depends on the design of the control system and physical database. The design of the physical database is also restricted by the specific control system. This influences the independence of the data, that is, we sacrifice some of the data's independence to obtain high realtime. For most control systems, especially medium- or mini-computer dedicated control system, data independence is not an unusually important characteristic. Thus, this type of trade-off is acceptable in a TDC system.

The process interface is essentially a simple mechanism for communication between the user and the physical database and between the process control system and the physical database. After this mechanism has been established in a database system, it forms a database management system (DBMS).

2. System Structure

In a TDC system, in addition to the abovementioned high realtime demand commands and queries, there are also some operations with high realtime demands. For example, for control system maintenance and configuration, including control system makeup and control parameter zhengding [2419 1353], these operations are operations of the control system in the formative process, and still do not initiate realtime control. Thus, the realtime demands of these operations are not high and they can be carried out through design of the conceptual database, so that it has higher data independence.

Summarizing the above, we can divide the operational language of the database into two parts: one part is the high realtime operations and queries, and the other part is the operations which do not have high realtime demands. The execution of the first group of operations are linked directly with the physical database through the process interface; the execution of the second group of operations is by linking the database management system and the physical database through the view and the conceptual database. In addition, the control system also communicates with the physical database through the process interface and does not directly link with the conceptual database. Thus, the logic structure of the TDC system is as illustrated in Figure 3.

This structure both maintains the general features of the database and also guarantees the realtime demands of the process control system.

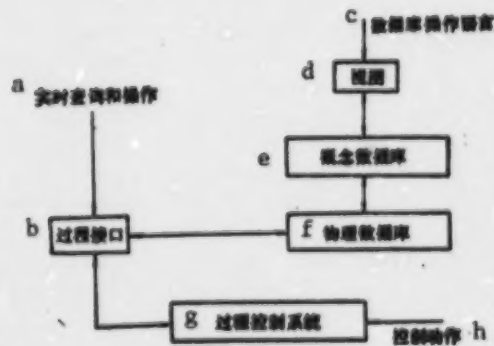


Figure 3

Key:

- a. Realtime queries and operations
- b. Process interface
- c. Database operation language
- d. View
- e. Conceptual database
- f. Physical database
- g. Process control system
- h. Control action

Database Operation Language

When database techniques are applied to realtime industrial process control, designing a suitable operation language is an important problem. Since a realtime control system user is frequently an operation worker or technician who is familiar with analog instruments, the operation language design should take this situation into consideration. For this, the QBE language first proposed by the IBM Company's M. Zloof in 1975 is clearly superior. However,

QBE language is a two-dimensional list format language, and all the operation and query results are presented in list format. Yet, in TDC systems, some more visual displays (including graphs and flow charts) are required. We feel that on the foundation of the original QBE language, based on the demands of a TDC system, it is appropriate to make suitable expansions in the requirements of conceptual and query function in order to adapt to the needs of control system operation. For basic knowledge concerning the QBE language, please see References [1], [2], and [3].

1. Relational Units Presentation Schema

Suppose that $\{R_i | i=1, \dots, n\}$ is a database schema. It is the set of all relational schemas in the database, for all i , suppose $S_i = \{A_j | j=1, \dots, m\}$ is the set of all attribute domains in R_i , and G_i is a plane figure,

$$t_i: S_i \rightarrow G_i$$

is a map so that $t_i(A_j^j) \cap G_i (j=1, \dots, m)$ is the subset within G_i , thus we say that (G_i, t_i) is the unit presentation schema of the relation R_i . ($i=1, \dots, n$)

According to this definition, as long as different (G_i, t_i) are defined for different control systems, the same database schema can provide different unit presentation schemas, i.e., provide people a different display form. The unit presentation schema must be defined when the system is formed. Once the unit presentation schema has been defined, there will be no changes in later operation and operation processes. The unit presentation schema is a display form that depends on a specific control system.

Example 1. Suppose that PP is a relation which has control loops (N) and some of its process parameter attributes. This can be expressed as

$$PP(N, PV, SV, MV)$$

in which N is the loop number, PV is the measurement value, SV is the given value, and MV is the operations output value. These are all attributes of PP. Defining G and t appropriately can provide the unit presentation schema of the PP relation as illustrated in Figure 4.

At this time, $G = \pi$

$$t(N \text{ field}) = \text{field } N$$

$$t(PV \text{ field}) = \text{line segment } AB;$$

$$t(SV \text{ field}) = \text{line segment } EF;$$

$$t(MV \text{ field}) = \text{line segment } CD.$$

To understand the process parameters, we use the query statement

PP	N	PV	SV	MV
	T 101	P.	P.	P.

The query results are as illustrated in Figure 5.

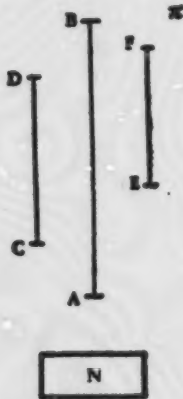


Figure 4

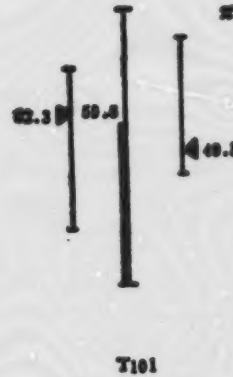


Figure 5

Example 2. Suppose SP is a relation which has a control loop and its system parameter attributes, which we express as:

SP (NP,P,I,D,T)

in which N is the loop number, P is the proportional coefficient, I is the integral coefficient, D is the differential coefficient, and T is the control period. Defining G and t appropriately we can get the unit presentation schema of the SP relation as illustrated in Figure 5.

To understand the relation situation of the system, we use the query statement

SP	N	P	I	D	T
	T 101	P.	P.	P.	P.

The results of the query are as illustrated in Figure 7.

P = P
 I = I
 D = D
 T = T

N

Figure 6

P = 201.5
 I = 1
 D = 0
 T = 1

T:01

Figure 7

2. Expansion of Query Functions

(1) Presentation Schema of Natural Linkage

To expand the functions of the QBE language, first of all we define the concept of the natural linkage presentation schema. Directly stated, it puts together two views according to a natural mode. It is defined as follows:

Suppose (G_1, t_1) , (G_2, t_2) are the unit presentation schema of the relations R_1 and R_2 , respectively, and S_1, S_2 are the attribute field set of the relations R_1 and R_2 , and supposing that R is the natural linkage of R_1 and R_2 , written as: $R = R_1 | x | R_2$. Let $G = G_1 + G_2$, in which "+" represents the linkage operation of the two views. Suppose $S = \{A_k\} = S_1 \cup S_2$, is the set of all the attribute fields in R_1 and R_2 , $t: S \rightarrow G$ is a map, so that

$$t(A_k) = \begin{cases} t_1(A_k) & \text{当 } A_k \in S_1 \\ t_2(A_k) & \text{当 } A_k \in S_2 - S_1 \end{cases}$$

hence it is said that (G, t) is the unit presentation schema of natural linkage R .

From the definition we know that, generally speaking, the unit presentation schema of $R_1 | x | R_2$ and $R_2 | x | R_1$ is different.

Using the same method, we can define the unit presentation schema of K relational natural linkages. Its definition is as follows:

$$| \times | R_1 = (| \times | R_1) | \times | R_k$$

Example 3. Suppose PP, SP and their unit presentation schemas are as described in Examples 1 and 2. Then the unit presentation schema of the natural linkage

$$R=PP|x|SP$$

is as illustrated in Figure 8.

Similarly, the unit presentation schema of $R=SP|x|PP$ is as illustrated in Figure 9

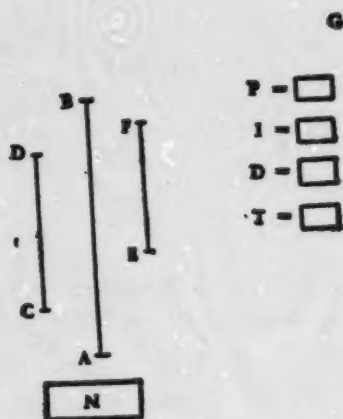


Figure 8

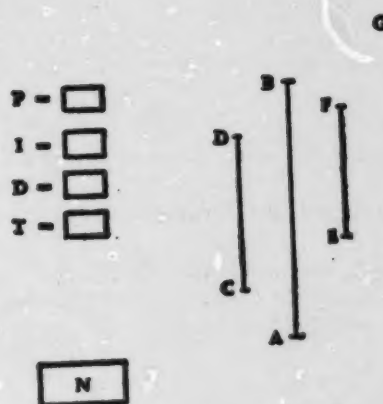


Figure 9

(2) Unconditional Queries

In the QBE language, in the format, a P is prefixed before the example elements of certain attribute ranks. The operation, expresses a query with regard to the attribute in the relation and prints out the result of the query. However, if a P is prefixed to a constant element, the operation is meaningless. Yet, we would like to give this operation a special meaning, i.e., it expresses the unit in the entire database through certain relational queries and in the other relations related to the designated attribute value. Below we describe this operation in detail. See References [2] and [3] for definition of example elements and constant elements.

Suppose the relational database schema:

$R=\{R_i(A_{i1}, \dots, A_{in_i}) \ i=1, \dots, m\}$, in which $R_j(A_{1j}, \dots, A_{n_jj})$ is the relation which has n_j attributes $A_{1j}, \dots, A_{n_jj}$. The attributes need not be different for different R_s .

Supposing that R_k is a certain relational schema in a relational database, A_k is an attribute of R_k , and is a constant element, then Operation I:

R_k	A_{k1}	...	A_{k3}	...	A_{kn_k}
-------	----------	-----	----------	-----	------------

P.a

indicates that first of all relations of all attribute A_{kj} in the database are naturally linked to obtain a new relation expressed as R_A , i.e.,

$$R_A = |x| R_1$$

(in which R_1 at least has the attribute A_{k1})

Supposing R_A has l attributes $A_1, A_2, \dots, A_l$, let $A_s = A_k$ ($1 \leq s \leq l$) then operation I is equivalent to the ordinary sense of the operation in QBE language:

R_A	A_1	...	A_s	...	A_l
-------	-------	-----	-------	-----	-------

P. a

(3) Conditional Query

Sometimes we hope to localize within a certain range the query and the relational unit related to the designated attribute values. This range can be realized through a query with a conditional box.

For example, R_k, A_{kj} etc., are as described in the Second Section, we have the operation II,

R_k	A_{k1}	...	A_{kj}	...	A_{kn_k}	Condition
-------	----------	-----	----------	-----	------------	-----------

P.a

$$\begin{matrix} |x| & R_j \\ \{R_j\}C\{R_1\} \end{matrix}$$

in which $\{R_j\}C\{R_1\}$ expresses the subset of the relational set of all attributes A_{kj} . Let $R'_A = |x| R_j$, supposing R'_A had l' attributes $A'_1, A'_2, \dots, A'_{l'}$, supposing $A'_t = A_{kj}$ ($1 \leq t \leq l'$), then Operation II is equivalent to the sense of the operation in the QBE language:

R_A'	A_1'	...	A_t'	...	A_1'
P.			a		

Here the sole difference between Operation I and Operation II is that R_A' is given by the condition in the conditional box.

Thus, Operation II will print out all the unit designated by the value a of attribute A_{kj} in R_A' . This is equivalent to finding more detailed information about an entity in a database through a relation R_1 .

Example 4. Suppose that in a database only the PP relation in Example 1 and the SP relation in Example 2 have a relation relevant to N (loop number) attributes. In Example 3 we gave the unit presentation schema $R=PP|z|SP$ as illustrated in Figure 8. Then the results of the query of operation;

PP	N	PV	SV	MV
----	---	----	----	----

P.T101

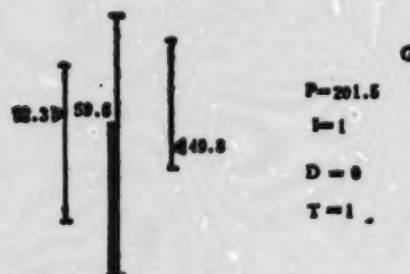
are as illustrated in Figure 10.

Similarly, the results of the query of operation:

SP	N	P	I	D	T
----	---	---	---	---	---

P.T101

are the same.



T101

Figure 10

REFERENCES

1. Ullman, J.D., PRINCIPLES OF DATABASE SYSTEMS, Computer Science Press, Potomac, MD 1980.
2. Su Yongle [5685 3057 2867], QBE YUYAN DAOPYIN [INTRODUCTION TO QBE LANGUAGE], GONGYE YIBIAO YU ZIDONGHUA ZHUANGZHI [INDUSTRIAL INSTRUMENTATION AND AUTOMATION], 1985, Nos 1,2.
3. M.M. Zloof, QUERY-BY-EXAMPLE: A DATABASE LANGUAGE, IBM System Journal, Vol 16, No 4, 1977.

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COUPLING FREQUENCIES OF RAMAN FREE-ELECTRON LASERS

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6, No 3, Mar 86
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[Text] Abstract: Analytical expressions of coupling frequencies of Raman free-electron lasers are deduced based on the physical image of the coupling between negative energy space charge wave and electromagnetic wave. Formulas are presented for different operation schemes. Under certain limiting conditions, these formulas are reduced to the familiar approximate expressions in the literature. Experimental results have borne out our analysis.

I. Introduction

The mechanism of a Raman free electron laser may be regarded as a coupling between the negative energy space charge wave in the electron plasma and the positive energy electromagnetic wave and the resulting coherent amplification of the latter. In the absence of a static magnetic wiggler (undulation) field in space, the dispersion curves of the negative energy space charge wave and the positive energy electromagnetic wave do not cross and there will be no coherent amplification of the radiation. The role of the wiggler field is to shift the dispersion curve of the space charge toward that of the electromagnetic wave so that they cross each other and result in a coupled amplification. The coupling frequency and the wave number are determined by the position of the intersection.

We analyzed the coupling frequency of the Raman free electron laser under different conditions. Calculations were made for a single energy relativistic electron beam propagating along the guiding magnetic field B_0 in the z direction in free space (or in a wave guide tube) and passing through a right-polarized static magnetic wiggler field with a wave number k_w . Naturally, the parameters of the electron beam, the guiding field, and the wiggler must all meet the Raman criteria.¹⁻³

Based on the theoretical analysis, we conducted an experimental study of the Raman free electron laser and obtained laser output. Preliminary parametric studies showed that the theory was correct.

II. Dispersion Curve of a Negative Energy Space Charge Wave in a Wiggler Field

Figure 1 shows schematically the phase relationship along the z axis of the wiggler field (or transverse velocity field), the electromagnetic wave and the space charge wave for electromagnetic wave amplification. The energy equation of the interaction between the electromagnetic wave with an electric field component E and the free electron laser with a transverse velocity v is

$$\dot{\gamma} = -\frac{ev_z E}{\sigma m}, \quad (1)$$

If $\dot{\gamma} < 0$, electromagnetic amplification is obtained. If v_z and E reach their respective simultaneously at a certain point in space, then, to maintain a maximum negative value of $\dot{\gamma}$, E should have an opposite maximum when the space charge wave passes through one half a period ($\lambda_w/2$) of the wiggler field; that is,

$$\lambda_w/2\lambda = \lambda_w/2\lambda_s - 1/2, \quad (2)$$

where λ and λ_s are respectively the wavelengths of the electromagnetic wave and the space charge wave. (2) can also be written as

$$k = k_s - k_w, \quad (2)'$$

where $k = 2\pi/\lambda$, $k_s = 2\pi/\lambda_s$, $k_w = 2\pi/\lambda_w$. (2)' is the relationship between the wavelengths of the electromagnetic radiation and the space charge wave.¹⁻³ It clearly shows that when the dispersion curve of the space charge wave in the (ω, k_d) coordinate system is replotted in the (ω, k) coordinate system, the curve will be shifted along the k axis by k_w . This translation causes the two nonintersecting curves to cross and leads to the free electron laser radiation.

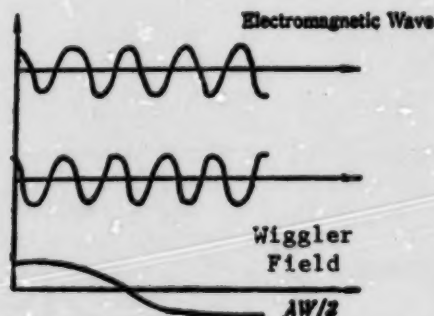


Fig. 1 Schematic of the phase relationship among wiggler field, EM wave and space-charge wave in a free-electron laser

III. Free Space Coupling Frequency Caused by Negative Energy Electrostatic Beam Mode

In the coordinate system (the primed coordinates) of particles moving along the z axis with velocity v_z , the electrostatic beam mode dispersion relation (negative energy branch) of the electron beam plasma⁴ is

$$\omega'_s = -\omega_p, \quad (3)$$

where ω'_s is the electrostatic beam mode frequency in the particle coordinates, $\omega_p = \sqrt{4\pi n e^2 / \gamma_s m}$ is the plasma characteristic frequency (or response frequency), $\gamma_s = 1/\sqrt{1-\beta_s^2}$ is the relativity factor determined by the v_z velocity of the electron beam, $\beta_s = v_s/c$, n is the electron density in the laboratory frame of reference, and e and m are respectively the electron charge and mass. From the relativistic Doppler relation

$$\omega'_s = \gamma_s(\omega - v_s k_z), \quad (4)$$

we obtain the dispersion relation of the negative energy electrostatic beam mode in the laboratory frame of reference, shown in Figure 3 as a dotted line:

$$\omega = v_s k + v_s k_z - \omega_p / \gamma_s. \quad (5)$$

On the other hand, the dispersion equation⁴ for the right-handed circularly polarized electromagnetic wave propagating along the z axis in the particle frame of reference is

$$\omega'^2 - c^2 k'^2 - \frac{\omega_p'^2 \omega'}{\omega' - \Omega_s} = 0, \quad (6)$$

where ω' and k' are respectively the frequency and wave number of the electromagnetic wave in the particle frame, $\Omega_s = e B_0 / m c$ is the cyclotron frequency, and B_0 is the guiding field in the z direction.

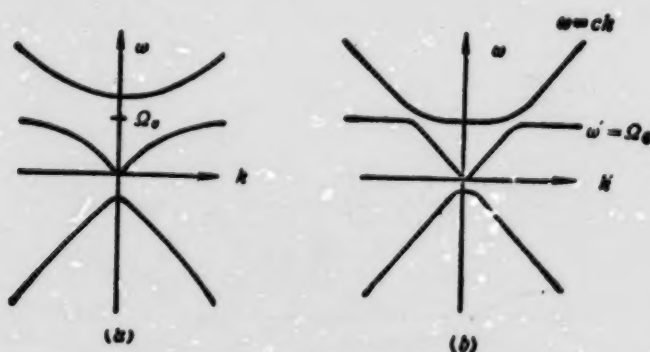


Fig. 2 Dispersion curves of EM wave in particle reference frame
(a) General case ($\omega_p \geq \Omega_s$); (b) $\omega_p < \Omega_s$

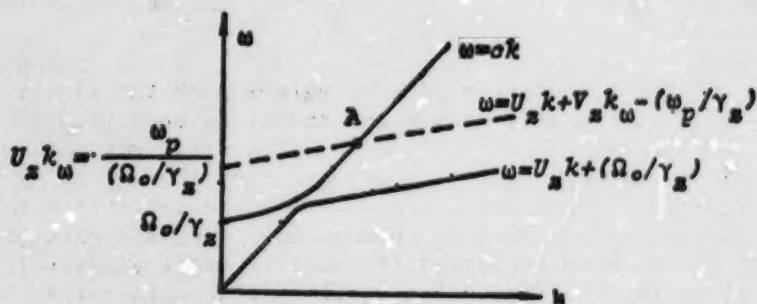


Fig. 3 Dispersion curves of EM wave (solid curve) and negative-energy space-charge wave (dash curve) in lab reference frame

$$\left(\frac{\Omega_0}{\gamma_s} < \left(v_s k_s - \frac{\omega_p}{\gamma_s} \right), \omega_p < \Omega_0 \right)$$

Figure 2(a) shows the general curve shape of Equation (6). When $\omega_p \ll \Omega_0$ the curve is shown in Figure 2(b) and approaches the three straight line sections of $\omega' = \Omega_0$ and $\omega' = \pm \alpha k'$. Note that $\omega_p \ll \Omega_0$ is not necessarily satisfied, especially at low electron beam energy.

Using the relativistic Doppler equation $\omega' = \gamma_s(\omega - v_s k)$, and $k' = \gamma_s(k - v_s \omega/c^2)$, we obtain the corresponding Equation (6) in the laboratory frame:

$$(\omega^2 - k^2 c^2) - \frac{\omega_p^2 (\omega - k v_s)}{(\omega - k v_s - \Omega_0 / \gamma_s)} = 0. \quad (7)$$

The general shape of (7) is shown as the solid lines in Figure 3, where A is the intersection and its corresponding frequency is the coupling frequency of the Raman free electron laser. It should be pointed out that in our simplified treatment only the real parts of ω and k are involved.

The frequency ω and the corresponding wave number k are found from (7) and (5):

$$\omega = \gamma_s^2 \alpha \pm \gamma_s^2 \alpha \left[1 - \frac{\omega_p^2}{\gamma_s^2 \alpha (\alpha - \Omega_0 / \gamma_s)} \right]^{1/2}, \quad (8)$$

$$k = \frac{\beta_s \gamma_s^2 \alpha}{c} \pm \frac{\gamma_s^2 \alpha}{c} \left[1 - \frac{\omega_p^2}{\gamma_s^2 \alpha (\alpha - \Omega_0 / \gamma_s)} \right]^{1/2}, \quad (9)$$

where $\alpha = v_s k_s - \omega_p / \gamma_s$. Since the wave is propagating in the positive direction, the positive sign should be chosen in (8) and (9). When the condition $\omega_p^2 \ll \gamma_s^2 \alpha (\alpha - \Omega_0 / \gamma_s)$ is satisfied, (8) may be approximated by

$$\omega \approx \frac{v_s k_s - \omega_p / \gamma_s}{1 - \beta_s} - \frac{\omega_p^2 \beta_s}{2 \alpha (\alpha - \Omega_0 / \gamma_s)}. \quad (10)$$

Note that the condition implies that ω_p is far less than ω and Ω_0 is far away from the magnetic resonance point $v_z k_x \gamma_z$.

The first term on the right hand side of (10) agrees with the expression derived by Marshall et al.⁵ from momentum and energy conservation for an ideal case and for $\omega_p \ll \omega$. The second term is a correction term, which makes the coupling frequency given by (10) slightly greater than that given by Reference 5 when B_0 is large ($\Omega_0 > \gamma_z \alpha$). Conversely, when $\Omega_0 < \gamma_z \alpha$, the correction term will make the frequency lower. When Ω_0 approaches $\gamma_z \alpha$, the assumption leading to (10) no longer holds true and (8) must be used. $\Omega_0 = \gamma_z \alpha$ is a singularity, as can be seen in Figure 3 as well. At this time the dispersion curve of the negative energy electrostatic beam mode ($\omega = v_z k + \alpha$) coincides with the asymptote of the electromagnetic dispersion curve ($\omega = v_z k + \Omega_0/\gamma_z$) and ω and k undergo large change in the vicinity.

It should be noted that the transverse velocity of the electron according to the stable orbit theory⁶ is given by

$$v_1 = \Omega_W v_z / (\Omega_0 - \gamma_z v_z k_W), \quad (11)$$

where $\Omega_W = eB_W/mc_0$. The singularity is also at $\Omega_0 = \gamma_z \alpha$, where $v_1 \rightarrow \infty$. The singularity should be avoided in a real device as it can cause rapid dispersion of the electron beam energy.

IV. Effects of the Waveguide Dispersion on the Coupling Frequency

The derivations above are for an infinite free space whereas the electron beam actually propagates in a waveguide tube, corrections must be made for the electromagnetic dispersion relation. To simplify the problem, we assume that $\omega_p^2 \ll \omega^2$ is true and that the singularity point is far away, Equation (7) in the waveguide becomes

$$\omega^2 - v_z^2 k^2 - \omega_{ce}^2 \approx 0, \quad (12)$$

where $\omega_{ce} = 2\pi c/\lambda_{ce}$ is the waveguide cutoff frequency and λ_{ce} is the cutoff wavelength.

From (5) and (12), it is easy to show that, for the electrostatic beam mode, the free electron laser coupling frequency is

$$\omega = \gamma_z^2 \left(k_W v_z - \frac{\omega_z}{\gamma_z} \right) \left\{ 1 \pm \left[\beta_z^2 - \frac{\beta_z^2 \omega_{ce}^2}{\left(\frac{\omega_z}{\gamma_z} - k_W v_z \right)^2 \cdot \gamma_z^2} \right]^{1/2} \right\}, \quad (13)$$

When ω_z/γ_z is negligible in comparison to $k_W v_z$, we have the approximate relationship

$$\omega \approx \gamma_z^2 k_W v_z \left[1 \pm \left(\beta_z^2 - \frac{\omega_{ce}^2}{\gamma_z^2 k_W^2 v_z^2} \right)^{1/2} \right]. \quad (14)$$

This equation shows that, to achieve the coupling between the space charge wave mode and the electromagnetic mode, the following inequality must be satisfied:

$$\lambda_{\text{free}} < \frac{\lambda_w}{\gamma_s(1+\beta_s)}, \quad (15)$$

where $\lambda_{\text{free}} = 2\pi c/\omega_{\text{free}}$ and is the coupling wavelength in free space. When γ_s is small (low energy electron beam), (15) is not automatically satisfied. In fact, (15) shows that the "effective" cutoff frequency of the waveguide is increased by a factor of $\gamma_s(1+\beta_s)$. For example, for an electron beam with $\gamma = 2$, this factor is almost 4. In assure normal operation, the radius a of the waveguide often has to be large (because $\omega_{\text{free}} \propto 1/a$); however, for a double spiral oscillator, the excitation current I_w of the wiggler is directly proportional to $\exp(5.68a/\lambda_w)$ for fixed k_w and B_w , an increase in the radius will cause a rapid increase in the excitation current I_w and lead to technical difficulties.

Figure 4 shows the variation of the parameter $\lambda_{\text{free}} \cdot \gamma_s(1+\beta_s)$ in (15) as a function of the guiding field B_0 for $\gamma = 3.5$ (accelerator voltage 1.25 MV) and $\gamma = 2$ (accelerator voltage ≈ 0.5 MV). It is clear that a radius drift tube with a radius $R_d = 5.5$ mm works for $\gamma = 3.5$ but not for $\gamma = 2$ over the entire range of (15). Since we had $\gamma = 2$, we chose an $R_d = 10$ mm.

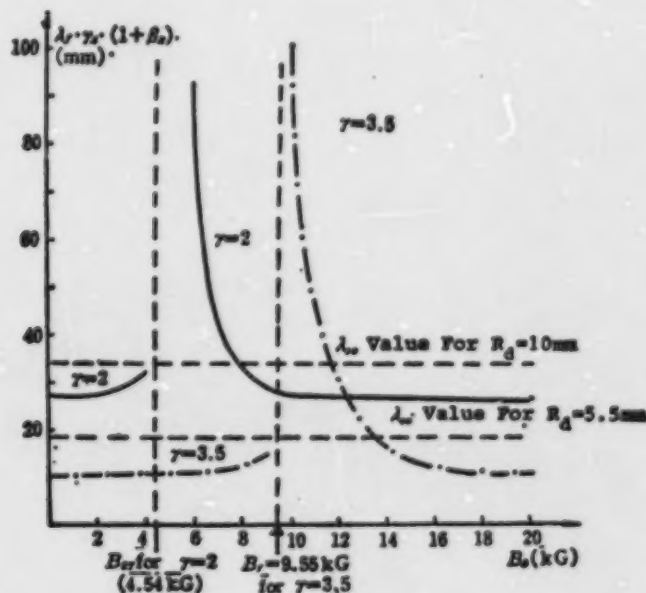


Fig. 4 Parameter $\lambda_{\text{free}} \cdot \gamma_s(1+\beta_s)$ versus B_0

$\lambda_w = 3$ cm; λ_{cutoff} - cutoff wavelength for TM_{11} mode; $\gamma=2$ curve: $B_w = 0.5$ kG, $I = 1$ kA;
 $\gamma=3.5$ curve: $B_w = 0.63$ kG, $I = 1.2$ kA

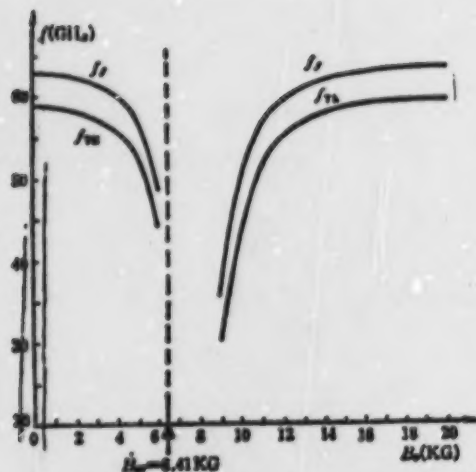


Fig. 5 Coupling frequency in free space f_f and in waveguide (TE_{11} mode) versus guiding magnetic field B_0

($\gamma=2$, $I=1$ kA, $r_s=0.3$ cm, $R_d=1$ cm,
 $\lambda_w=2.25$ cm, $B_w=0.5$ kG)

Figure 5 shows the free space coupling frequency f_f and the TE_{11} mode coupling frequency f_{TE} in a 20 mm diameter drift tube versus B_0 for $\gamma=2$. The difference between f_f and f_{TE} is clearly evident.

Figure 6 shows the effect of the wiggler field B_w on the coupling frequency of the TE_{11} mode when $\gamma=2$. Figure 7 shows the effect of the wiggler wavelength λ_w on the coupling frequency of the TE_{11} mode and the transverse velocity β_1 of the electron for the case of $\gamma=2$. In the $\lambda_w < 2.25$ cm region, f_{TE} decreases with decreasing λ_w . This is because that β_1 increases as the magnetic resonance singularity is approached (see Equation (11)). Our experiments were for $\lambda_w = 2.25$ cm and $\lambda = 2.2$ cm.

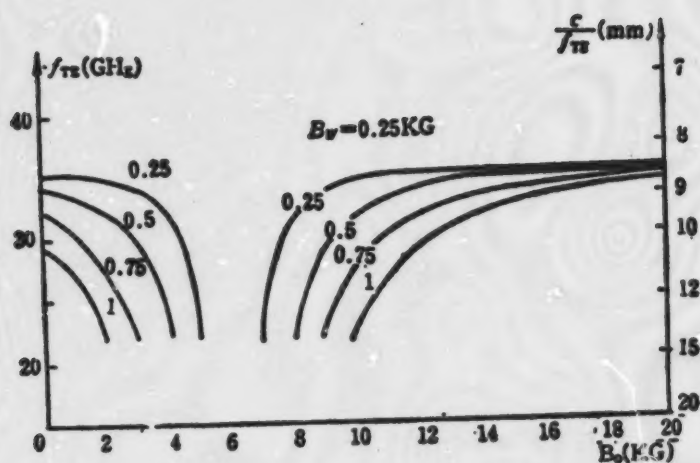


Fig. 6 TE_{11} mode coupling frequency versus B_0 for different wiggler fields
($\gamma=2$, $I=1$ kA, $r_s=0.3$ cm, $R_s=1$ cm, $\lambda_w=3$ cm)

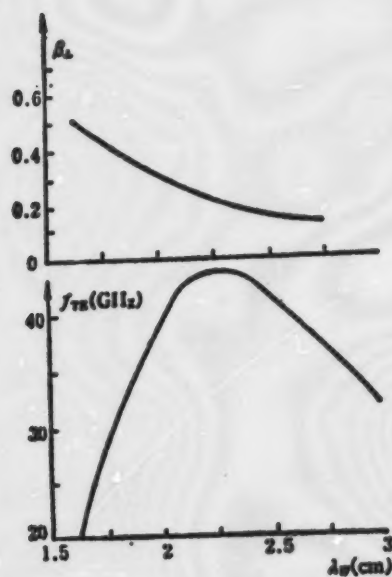


Fig. 7 Transverse velocity of electrons β_1 and TE_{11} mode coupling frequency f_{TE} versus wiggler period λ_w
($\gamma=2$, $I=1$ kA, $r_s=0.3$ cm, $R_s=1$ cm, $B_w=0.5$ kG, $B_0=10$ kG)

As can be seen from Figures 4-7, the coupling frequency is affected by a number of complex factors. In selecting the optimum operating condition of an overall design, the gain calculation must also be brought in. Based on the above theoretical analysis, we conducted an instrument design and testing. A high current electron beam (0.5 MeV, 1 kA) emitted from a carefully designed foil-less diode tube was guided by a strong axial magnetic field and formed a 1 meter tall highly collimated column (or hollow column) in the drift tube. This column of electron beam served as the lasing material. A right-hand circularly polarized double winding wiggler with a period λ_w of 2.2 cm or an axially symmetric iron ring wiggler with a period λ_w of 2.25 cm was used as the pumping source. In both cases free electron laser radiations (coherent radiation amplification mode) were obtained. The laser parameters were measured to be: width at half maximum = 20 ns, average power = 0.5 MW, electron efficiency $\approx$ 0.1 percent, and wavelength of the K_α branch $\approx$ 8 mm.

Preliminary parameteric studies showed that the optimum operating region is in the vicinity of $B_0 = 9$ kG and $B_w = 0.5$ kG. The results are consistent with Figures 4-7 and the calculated laser wavelength of 7 mm is also in agreement with the measured value. Details of the experiment and the results will be published elsewhere.

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References

1. P. Sprangle, et al., in "Infrared and Millimeter Waves," (Academic Press), 1979, 1, chapter 7.
2. H.P. Freund, et al., Phys. Rev. A, 1981, 24, No 4 (Oct), 1965.
3. H.P. Freund, et al., Phys. Rev. A, 1982, 26, No 4 (Oct), 2004.
4. J.D. Lawson, "The Physics of Charged-Particle Beams," (Thomson Ltd.), 1977.
5. T.C. Marshall, et al., in "Advances in Electronics and Electron Physics," ed. L. Marton and C. Marton, 1980, 53.
6. L. Friedland; Phys. Fluids, 1980, 23, No 12 (Dec), 2376.
7. Chu Cheng, et al., ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] Vol 12, No 12, 767(1985).

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APPLIED SCIENCES

TRANSFORMATION OF LASER BEAM THROUGH GLASS RING

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 1, Jan 86 pp 124-128

[Article by Zhang Guoshun [1728 0948 7311], Cheng Fuan [4453 4395 1344], Liu Le [0491 3157] and Wang Keqi [3769 0344 6386]]

[Text] Abstract: A new optical element--a glass ring--is introduced in this paper. The glass ring can transform a laser beam into a plate beam under certain conditions. The transformation is described in detail. The ring works like an optical fiber.

Some conclusions at different angles (from 0° to 90°) are obtained and the future applications are explained.

Introduction

The laser beams produced by a resonance cavity are usually one-dimensional beams with a high degree of directionality. Two-dimensional planar laser beams are more difficult to produce. Two dimensional operation of certain high gain materials has been reported^{2,5}; for example, a two-dimensional planar laser beam has been produced by Rhodamin 6G dye in a cylindrical glass cavity and the multiple reflection within the cylinder formed a resonance cavity. Such operation is difficult to achieve in more commonly used lasers. Methods for converting a 1-D laser beam with an optical device into a 360° 2-D planar laser light has never been reported.

The ring lens reported here is a section of optical glass tube with cylindrical inner and outer surfaces. the laser beam enters the glass ring from one side and a planar laser beam is obtained when certain conditions are satisfied by the incidence angle. This device may be applied in situations where a reference plane or a 2-D planar laser is required.

I. Principle and Experiment

Figure 1 shows the propagation of a meridian light in a fiber optics. The angle of incidence β at the interface must exceed the critical angle to ensure total reflection. When the light ray propagates to the curved part, the incidence angle at the inner surface α increases and the incidence angle at the outer

surface β decreases. When β becomes less than the critical angle and if the radius of curvature is small, the totally reflecting meridian ray at the straight section will escape through the outer surface when it reaches the curved section.

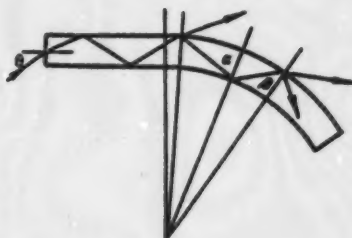


Fig. 1.

Based on the above principle, we conducted the following experiment. A beam of He-Ne laser was first directed toward the center of the glass ring so that the beam is normal to the axis of the ring and coincide with the x axis, as shown in Figure 3. The ring was then moved slowly along the y axis so that the distance H between the incident beam and the x axis varied between 0 and $R + d$. It was found experimentally that when H fell within a certain range (see next section), the laser beam was transformed into a 2-D planar beam filling up all 360° . When the planar beam was intercepted by a surrounding screen, a closed bright line was observed. In certain regions the bright line consisted of alternating bright and dark dots. When smoke was applied around the ring, the planar laser beam became clearly visible, as shown in Figure 2.

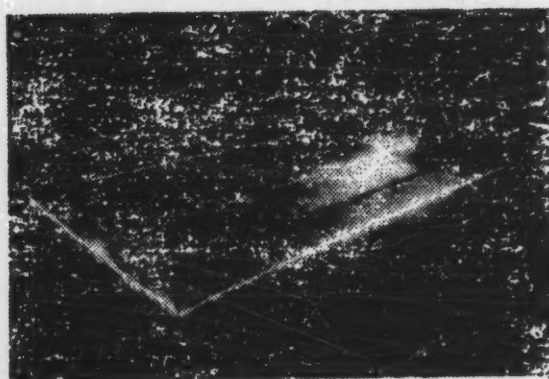


Fig. 2.

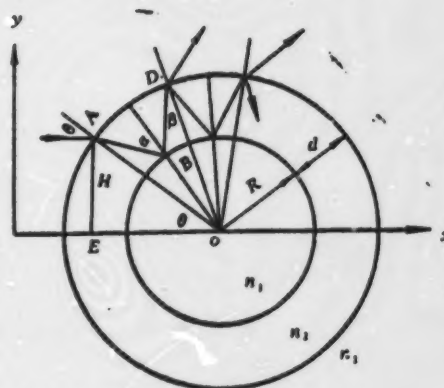


Fig. 3.

II. Optical Path Analysis

The angle α in Fig. 3 is the critical angle and the He-Ne laser beam enters with an incidence angle θ at point A. The inner radius of the ring is R and the outer radius is $R + d$, where d is the thickness. If the refractive index of the ring is n_2 and the refractive index of the surrounding medium is n_1 , then,

$$\sin \alpha = \frac{n_1}{n_2} \quad (1)$$

$$\sin \angle OAB = \frac{R}{R+d} \cdot \sin \alpha = \frac{n_1}{n_2} \cdot \frac{R}{R+d}$$

$$\text{From } \sin \theta = \frac{n_2}{n_1} \cdot \sin \angle OAB$$

$$\sin \theta = \frac{R}{R+d} \quad (2)$$

For the incidence angle on the inside of the ring to be critical, θ must be equal to $\sin^{-1}(R/R+d)$ and this is independent of the refractive index of the material. Since $\sin \beta/R = \sin \alpha/R+d$, angle β is less than angle α . That is, when the incidence angle on the inner surface is critical, the incidence angle β on the outer surface is less than critical and some light will escape. The laser beam bounces repeatedly between the inner and outer walls of the ring and a planar laser beam is formed by refraction.

In Figure 3 $AE = H$ is the vertical distance from the incidence point to the x axis. From the diagram, $\sin \theta = H/R+d$. When α is the critical angle, a comparison with (2) shows that

$$H = R \quad (3)$$

When H increases and the refracted light becomes tangent to the inner circle, as shown in Figure 4, we have

$$\sin \theta = \frac{n_2}{n_1} \cdot \frac{R}{R+d} \quad (4)$$

Hence, $H = \frac{n_2}{n_1} R$. When the surrounding medium is air ($n_1=1$), we have

$$H = n_2 R \quad (5)$$

If the glass ring is made of k9 optical glass, $H = 1.52R$. When the incidence angle θ continuous to increase and H becomes greater than $n_2 R$, we have the

situation shown in Fig. 5, where β is less than the critical angle. Therefore, incident rays with $H > n_2 R$ will have their refracted rays missing the inner circle. Some light will escape at each reflection and refraction. The maximum reflection angle β is the critical angle, when $\theta = 90^\circ$, β is equal to the critical angle.

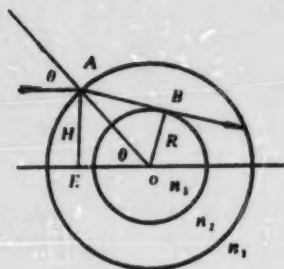


Fig. 4.

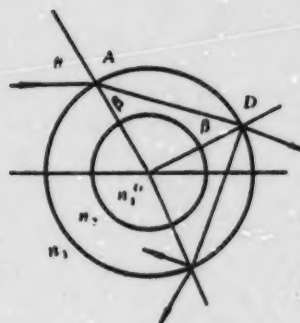


Fig. 5.

Figure 6 shows the optical path for $H < R$, or small θ . At this time α is less than critical and

$$\sin \gamma = \frac{R+d}{R} \sin \theta \quad (6)$$

where $\sin \theta < \frac{R}{R+d}$. The light ray entering the ring will undergo multiple reflections and some light will escape at each reflection.

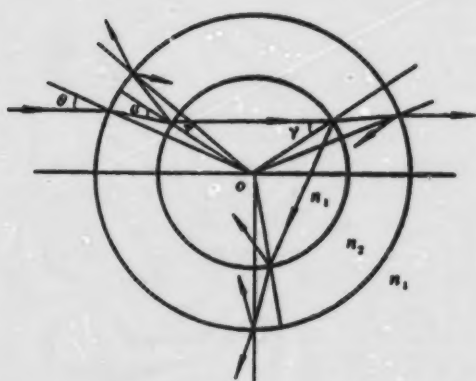


Fig. 6.

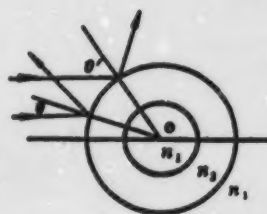


Fig. 7.

This will lead to intensity inhomogeneity of the planar laser beam and should be avoided.

Figure 7 shows the incident light reflecting from the outer surface. Since the incident beam has a finite width, the beam contains different angles of incidence. Reflection at the circular surface causes the reflected rays to propagate in different directions. This also causes intensity variation and measures should be taken to reduce the outer surface reflection. Moreover, rays reflected from the inner and outer surfaces may interfere and form alternating unequally spaced dots^{4,6}.

For light rays incident on the glass ring perpendicular to the axis of the ring. Figure 6 depicts the situation when $H = 0$ —R, Figure 3 shows the condition $H = R$ to n_2R , and Figure 5 shows the condition $(R + d) > H > n_2R$.

Neglecting the actual divergence angle of the beam or the Gaussian characteristics, then the case in Figure 3 is realized when the beam width is equal to $(n_2 - 1)R$ and H is between R and n_2R . The range of the incidence angle is determined by R and d and is independent of n_1 and n_2 .

III. Conclusions

A 2-D planar laser beam can be produced by the glass ring. Any application that calls for a planar laser beam may use the glass ring. The ring lens expands the range of application from one dimension to two dimensions.

Velocity measurement by a light net relies on the two signals when a light speed flying object passes two planar light beams. A microprocessor is used to calculate the average velocity between the two planes.

Applications in plane survey—The planar laser beam produced by the ring may be used directly for line drawing in architecture and ship building, indoor remodeling, and alignment of large buildings. With improved manufacturing process and installation accuracy of the ring, the planar light beam produced may serve as optical standards in accurate plane survey.

Flow field indication—An important task in the research of internal combustion engines in the display of the gas distribution in the cylinder. Since the planar laser beam can clearly show the distribution and flow of small particles in a mist, a number of planar laser beams may be used in the display of the flow field of gas vapors in the cylinders of an internal combustion engine.

In addition, the ring lens may find uses in defense research on light target, multipoint communication, and laser warning system. The ring lens may also be used in laser machining and laser display.

Judging from the experimental results, the ring lens is a valuable optical component. Ring lenses of different precision may be used in different applications. Special components may be designed according to the application.

For future work, the characteristics of the ring lens should be investigated in order to understand the light intensity distribution and the conditions for interference.

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REFERENCES

1. Mu Guoguang [3019 0948 0342] and Zhan Yuanling [2069 0337 0109], "Optics," People's Education Publishing Company, Sept 1979.
2. Wang Xipo [3769 6006 0980] and Peng Guifang [1756 2710 5364] of the Changchun Applied Chemistry Institute, article on two dimensional planar laser, Vol 3, No 1, 1983.
3. Xu Daxiong [1776 1129 7160], "Physical Basis of Fiber Optics," Advanced Education Publishing Company, Sept 1978.
4. "Laser Display Experiments," translated by Song Zhufeng [2646 4554 6265], People's Education Publishing Company, 1980.
5. Z. Gy. Horvath, A.A. Malyntin and A.V. Kilpio. Laser Focus 16, 1980, 32.
6. D.C. Brown and T.L. Rome, Am. J. Phys. V 40, p 470 March 72.

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CSO: 4008/62

Analytical Chemistry

COMPOSITION ANALYSIS OF COMBUSTION PRODUCTS OF TOWN GAS AND STUDIES ON CORRESPONDING EQUIPMENT WITH SBC DATA PROCESSING

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 2, Apr 86 pp 8-16

[English abstract of article by Jin Zhigang [6855 1807 0474], et al.]

[Text] This paper describes a self-designed continuous autoanalysis equipment of combustion products and explains the theoretical approach and technical measures taken. The new equipment has the following advantages:

1. increased precision,
2. considerable reduction of test time,
3. timely printing of combustion parameters: coefficient of excess of air α , CO content in dry and airfree flue gas $CO_{a=1}$, and ration CO/CO_2 ,
4. display of combustion parameters.

Results of experiments show that the equipment is a power-ful tool in investigating combustion performance. (Paper received 1 Dec 84.)

REFERENCES

- [1] 煤气燃烧及输配测试技术 金志刚 1981. 建工出版社
- [2] 支架对液化石油气灶烟气中CO浓度的影响 金志刚 李文H
1982.10 "城市煤气情报"
- [3] Gas Analysis Instrumentation A. Verdin 1973.

Catalysis

INVESTIGATION ON THE ADSORPTION AND REACTION OF n-BUTENE ISOMERS OVER FERRITE SPINELS WITH PULSE AND TPD TECHNIQUES

Beijing CUIHUA XUEBAO [JOURNAL OF CATALYSIS] in Chinese Vol 7, No 1, Mar 86
PP 1-8

[English abstract of article by Qiu Fengyan [6726 7685 3508], et al., of Lanzhou Institute of Chemical Physics, Academia Sinica]

[Text] Adsorption and reaction of n-butene isomers over α -Fe₂O₃, ZnFe₂O₄ and ZnCrFeO₄ were studied by means of pulse and TPD techniques. It is shown that the three butene isomers are adsorbed on the three oxides at approximately the same amount, but they react quite differently on them. At room temperature, three isomers show almost no reaction on α -Fe₂O₃; meanwhile, double bond migration and selective oxidation to butadiene occur distinctly over the two spinels to different extents. Results with multiple pulses of butenes on the two spinels demonstrate that the butadiene formation in the second pulse is much greater than that in the first, then it lowers again in the subsequent pulses. It is suggested that selective oxidation sites are generated on the two spinels through the action of the first butene pulse. The TPD spectra of butanes adsorbed at room temperature on the three oxides show two well-separated peaks: the low temperature peak (<200°C) consists of butene and butadiene; while the high temperature peak (200-600°C) is also a composite peak and consists of CO₂ only. The butenes retain strongly on the oxides except α -Fe₂O₃. Repeated TPD runs up to 600°C are required to "desorb" thoroughly the retained butenes. CO₂ is the sole product in subsequent TPD runs. Two modes of generation of selective oxidation sites on the spinels (reduction activation and heating activation) are suggested and plausible structures of surface species (both the adsorbed butene and active sites) in selective and total oxidations are discussed. (Paper received 2 Aug 84.)

REFERENCES

- (1) Massoth, F. E. & Scarpiello, D. A., *J. Catal.*, **21**, 294(1971).
- (2) Rennard, R. J. & Kehl, W. L., *ibid.*, **21**, 282(1971).
- (3) Kung, H. H., Kundalkar, B., Kung, M. C. et al., *J. Phys. Chem.*, **84**, 382(1980).
- (4) Kung, H. H., Kung, M. C. & Yang, B. L., *J. Catal.*, **69**, 508(1981).
- (5) 汪汉卿, 冯良波, 陈英武等, *中国科学*, **№9**, 876(1979).
- (6) 徐慧珍, 王青, *燃料化学学报*, **8**, 187(1980).
- (7) Gibson, M. A. & Hightower, J. W., *J. Catal.*, **41**, 420(1976).
- (8) *Idem.*, *ibid.*, **41**, 431(1976).

SYNCHRONOUS TRACKING TPD AND TPSR OF CO ON Pt/Al₂O₃ BY TC-GC TECHNIQUE

Beijing CUIHUA XUEBAO [JOURNAL OF CATALYSIS] in Chinese Vol 7, No 1, Mar 86
pp 9-14

[English abstract of article by Li Qiyuan [2621 0796 3293], et al., of Research Institute of Qilu Petrochemical Corporation, Zibo, Shandong]

[Text] CO TPD spectra on Pt/ γ -Al₂O₃ catalysts have been monitored by GC in step with thermoconductivity (TC) technique. Results showed that the TC-spectrum of desorbed CO is flat broad profile from 331 to 776K, which is similar to that reported by other authors. The GC-spectra indicated that there exist two peaks for CO or CO₂, of which the maximum temperatures T_{m1} and T_{m2} are 237, 384°C and 220, 309°C respectively. The effect of re-adsorption of CO on the broadening of spectra observed under our experimental conditions may be neglected, so the broadening of spectra is attributed to the existence of multi-chemisorption states of CO and CO₂. Raising the temperature of heat treatment of the catalysts in H₂ from 500 to 800°C for 6 hours, a considerable change of behaviors of adsorption and reaction for CO took place. The amount of adsorbed CO decreased from 96.6 to 68.6ml/g-Pt, but the ratio of CO₂ to CO in desorbed product increased from 0.69 to 2.25. There was only a single peak of CO₂ on the TPSR spectra in O₂-He carrier gas, of which the maximum temperature reduced from 231 to 76°C. From the TPD spectra after a period of CO oxidation in a gaseous mixture containing a major amount of H₂, it was found that the tendency to yield CO₂ was markedly enhanced. It is interesting that the CO reactivity characterized by TPD and TPSR corresponds to the selective oxidation activity measured by steady-state flow method. Under the given reaction conditions, the measured turnover frequency of CO selective oxidation on sample treated at 800°C was 3.1×10^{-2} mol/site.sec, it is thirty-three times as large as that on the sample treated at 500°C. However, in H₂-Ar carrier gas, TPSR spectra of adsorbed CO revealed that the methanation to CH₄ did not show obvious different from that of the sample treated at high temperature in H₂. (Paper received 21 Sep 84.)

REFERENCES

- (1) Falconer, J. L. & Schwarz, J. A., *Catal. Rev.-Sci. Eng.*, **25** (2), 141(1983).
- (2) Fujimoto, K., Kameyama, M. & Kunugi, T., *J. Catal.*, **61**, 7(1980).
- (3) Takahashi, M. et al., *ibid.*, **48**, 16(1976).
- (4) 伏羲路, 林培琅, 催化学报, **3**, 296(1982).
- (5) 徐慧珍, 陈惠功, 翁善至, 同上, **4**, 186(1983).
- (6) Fogar, K. & Anderson, J. R., *Appl. Surf. Sci.*, **2**, 395(1979).
- (7) Herz, R. K. et al., *J. Catal.*, **73**, 66(1982).
- (8) Tauster, S. J. et al., *J. Amer. Chem. Soc.*, **100**, 170(1978).

STUDIES OF $\text{Co}_2(\text{CO})_6(\text{PBu}_3)_2$ COMPLEX SUPPORTED ON ZrO_2 AND DISPERSED COBALT CATALYSTS

Beijing CUIHUA XUEBAO [JOURNAL OF CATALYSIS] in Chinese Vol 7, No 1, Mar 86
pp 15-21

[English abstract of article by Xu Huizhen [1776 1979 3791], et al., of Lanzhou Institute of Chemical Physics, Academia Sinica]

[Text] The decarbonylation of $\text{Co}_2(\text{CO})_6(\text{PBu}_3)_2$ supported on ZrO_2 and $\text{Zr}(\text{OH})_4$, and the adsorbed species of CO on the dispersed cobalt catalysts have been studied by IR spectroscopy, UV diffuse reflectance spectroscopy and temperature-programmed decomposition technique (TPDE). It is found that when the surface complex is heated in vacuum, the intensity of terminal carbonyl diminishes somewhat with increasing temperature, and the intensity of bridged carbonyl increases simultaneously. As the temperature is raised to 300°C , the carbonyl bands disappear completely. However, the C-H frequency bands persist in the IR spectra, showing the phosphine ligands still exist on the catalyst surface. When CO admitted to the dispersed catalysts after decarbonylation of supported complexes, it is noticed that at the time of exposing the catalysts with adsorbed CO to air, the frequency band of CO disappears at once. According to experimental results, two models of the $\text{Co}_2(\text{CO})_6(\text{PBu}_3)_2$ supported on ZrO_2 and $\text{Zr}(\text{OH})_4$ are proposed. The interactions of the $\text{Co}_2(\text{CO})_6(\text{PBu}_3)_2$ with the surface of ZrO_2 and $\text{Zr}(\text{OH})_4$ are also discussed respectively. When supported on ZrO_2 , the Co in $\text{Co}_2(\text{CO})_6(\text{PBu}_3)_2$ interacts with oxygen ions on ZrO_2 surface. $\text{Co}_2(\text{CO})_6(\text{PBu}_3)_2$ directly interacts with hydroxyl groups on $\text{Zr}(\text{OH})_4$ surface when supported on $\text{Zr}(\text{OH})_4$, hydrogen bonding occurs between the oxygen atoms of carbonyl ligands and the OH groups. At elevated temperature under vacuum, hydrogen bonding diminishes and partially decarbonylated complex is formed, which is similar to that supported on ZrO_2 . (Paper received 25 Aug 84.)

REFERENCES

- (1) Nakamura, R., Oomura, A. et al. *Chem. Lett.*, 1483(1982).
- (2) Iwasawa, Y., Yamada, M., Sato, Y. et al. *J. Mol. Catal.*, 23, 95(1984).
- (3) Schneider, R. L., Howe, R. F. & Watters, K. L. *J. Catal.*, 79, 298(1983).
- (4) 杨震宇, 罗玉忠, 刘惠德等, 催化学报, 1, 28(1988).
- (5) Abrahamson, H. B., Frazier, C. C., Glasey, D. S. et al. *Inorg. Chem.*, 16, 1554(1977).
- (6) Levenson, R. A. & Gray, H. B. *J. Amer. Chem. Soc.*, 97, 6042(1975).
- (7) Gardner, R. A. & Petrucci R. H., *ibid.*, 82, 8881(1960).

INFRARED STUDY ON THE CONVERSION OF METHANOL TO HYDROCARBONS ON HZSM-5 ZEOLITE

Beijing CUIHUA XUEBAO [JOURNAL OF CATALYSIS] in Chinese Vol 7, No 1, Mar 86
pp 22-27

[English abstract of article by Dong Qingnian [5516 1987 1628] of Shanxi
Institute of Coal Chemistry, Academia Sinica, Taiyuan]

[Text] Description of the catalytic action of HZSM-5 zeolite in published literatures usually emphasized the contribution of Bronsted acid sites, but the effect of Lewis acid sites was often neglected. The methanol adsorption and conversion on HZSM-5 zeolite were studied by means of in situ infrared spectroscopy. It was found that methanol was bound to Bronsted acid sites forming weak hydrogen bonds, but it was adsorbed on Lewis acid sites through strong chemical bonds. Consequently, the dehydration of methanol took place primarily on the Lewis acid sites to form dimethyl ether, the first intermediate. Therefore, it is obvious the Lewis acid sites also played an important role in the conversion of methanol to hydrocarbons. According to the IR spectra of methanol adsorbed on HZSM-5 zeolite at different temperatures, it was revealed that methanol reacted further with dimethyl ether thus produced to form high ether-like species on Bronsted acid sites in the range of 200-300°C. This implicated the beginning of carbon chain multiplication. Continuously raising the reaction temperature to above 300°C, polymerization, cracking and dehydration took place, and different kinds of hydrocarbons were produced. A proposed reaction scheme for the conversion of methanol was given. (Paper received 8 Sep 84.)

REFERENCES

- (1) Chang, C. D. & Silvestri, A. J. *J. Catal.* 47, 249(1977).
- (2) Deromano, E. G., Nagy, J. B. & Dejalfo, P. *ibid.* 53, 40(1978).
- (3) 小野高夫等, 触媒(日), 21, 388(1979).
- (4) Kagi, D. *J. Catal.* 69, 242(1981).
- (5) Kaeding, W. W. & Butter, S. A. *ibid.* 61, 155(1980).
- (6) 郭文雄, 梁耀, 赵素琴等, 催化学报, 5, 11(1984).
- (7) 张正, 傅昭恩, 刘裕第等, 燃料化学学报, 10, 59(1982).
- (8) 张正, 傅昭恩, 梁欣欣等, 同上, 12, 193(1984).
- (9) Vedrine, J. C., Auroux, A. et al. *J. Catal.* 59, 248(1979).
- (10) 郭文雄, 李勤, 张耀等, 催化学报, 2, 113(1981).
- (11) 王建民, 吕久茹, 石油化工, 11, 688(1982).
- (12) Topala, N. -Y. et al. *J. Catal.* 70, 41(1981).
- (13) 董庆年, 燃料化学学报, 11, 60(1983).
- (14) 杨玉华, 赖国长, 成都科技大学学报, No 1, 47(1983).
- (15) 陈国权, 蔡光宇, 王清源等, 燃料化学学报, 10, 308(1982).
- (16) Bellamy, L. J., "The Infrared Spectra of Complex Molecules", Chapman & Hall, London, 3rd Ed., 1975.
- (17) Bellamy, L. J., "The Infrared Spectra of Complex Molecules, Vol 2, Advances in Infrared Group Frequencies", Chapman & Hall, London, 2nd Ed., 1960.
- (18) Perchard, J. P., *Spectrochim. Acta*, 26A, 787(1970).
- (19) Wimer, H. & Laidlaw, W. G. *ibid.* 24A, 1055(1968).

THE STRUCTURAL CHANGES OF HZSM-5 ZEOLITES TREATED BY HIGH TEMPERATURE STEAM AND THEIR EFFECTS ON THE ALKYLATION OF TOLUENE WITH METHANOL

Beijing CUIHUA XUEBAO [JOURNAL OF CATALYSIS] in Chinese Vol 7, No 1, Mar 86
pp 28-34

[English abstract of article by Zeng Zhaoxue [2582 2507 2849], et al., of
Department of Chemistry, Zhongshan University, Guangzhou]

[Text] The structural changes of HZSM-5 zeolites treated by steam at various temperatures were studied by XRD, XPS, IR, TGA, TPD and vacuum vapor gravimetric absorption techniques, and the alkylation of toluene with methanol over the zeolites was examined by continuous-flow microreaction chromatography as well. Experimental results of HZSM-5 zeolites after steam treatment at 600, 700, 800 and 900°C for 6 hours respectively were as follows: The framework topology of zeolite samples was not destroyed as shown by the XRD patterns, but a change from orthorhombic symmetry to apparent monoclinic symmetry was observed. XPS analysis indicated that the aluminium atoms were removed greatly from the framework. IR spectra and TPD graphs revealed that the surface Bronsted acid sites and the acidic strength were decreased remarkably, the same conclusion might also be drawn from the TGA data. Adsorption data showed that the zeolite channels and pore openings would be twisted and/or contracted slightly.

When the alkylation of toluene with methanol was performed over the steam treated HZSM-5 zeolite catalyst, a high selectivity for p-xylene was obtained. This is attributed to the changes of surface acidity and channel structure of the zeolite, however, the former is the primary factor. It is considered that the temperature for steam treatment is not necessary to exceed 700°C, and for the methylation of toluene, the appropriate reaction temperature is 450 to 550°C. For example, alkylation of toluene over a 600°C steam treated HZSM-5 sample at a reaction temperature of 500°C gives 81.4 percent selectivity for p-xylene with a 29.8 percent toluene conversion. (Paper received 9 Jul 84.)

REFERENCES

- (1) Yashima, T., Ahmad, H., Yamazaki, K. et al. *J. Catal.* 16, 273(1970).
- (2) Yashima, T., Yamazaki, K., Ahmad, H. et al. *ibid.* 17, 151(1970).
- (3) Kaeding, W. W., Chu, C., Young, L. B. *ibid.* 67, 150(1981).
- (4) *U. S.* 3,905,209(1976).
- (5) Yashima, T., Sakaguchi, Y. & Namba, S. "Proceedings of the 7th International Congress on Catalysis", (Eds. Seiyama, T. & Tanabe, K.), Kodansha, Tokyo, p. 739, 1981.
- (6) 曾昭槐, 王炳瑜, 石油化工, 12, 309(1983).
- (7) Kerr, G. T., *J. Catal.* 15, 200(1969).
- (8) 孟中岳, 鲍书林, 周日新, 催化学报, 2, 209(1981).
- (9) *U. S.* 3,702,000(1972).
- (10) Wu, E. L., Lawton, S. L., Olson, D. H. et al. *J. Phys. Chem.* 83, 2777(1979).
- (11) 郭文瑾等, 催化学报, 2, 113(1981).
- (12) Jacobs, P. A., "Carbonogenic Activity of Zeolites", Elsevier, Amsterdam, p. 166, 1977.
- (13) Weisz, P. B., *Pure Appl. Chem.* 52, 2091(1980).
- (14) Wei, J., *J. Catal.* 76, 433(1982).

STUDIES ON THE ION EXCHANGED ULTRASTABLE Y TYPE (USY) ZEOLITES BY INFRARED SPECTROSCOPY

Beijing CUIHUA XUEBAO [JOURNAL OF CATALYSIS] in Chinese Vol 7, No 1, Mar 86 pp 40-45

[English abstract of article by Zhang Yingzhen [1728 4134 3791], et al., of Dalian Institute of Chemical Physics, Academia Sinica]

[Text] HY, CaHY, LaHY and the corresponding ultrastable treated USY, CaUSY, LaUSY zeolites were studied by means of infrared spectroscopy. In comparison with HY and USY, USYH obtained by further NH_4^+ ion exchange of USY was also examined.

It was found that the intensity of 3700cm^{-1} band of MeUSY depended not only on the content of Na^+ , but also on the content of other cations, such as Ca^{2+} and La^{3+} . Spectra in the region of OH stretching vibration showed that the presence of La^{3+} stabilized the skeletal OH groups in zeolites. The intensity of spectral band around 1545 and 1455cm^{-1} and its change at different desorption temperatures of pyridine were examined for characterizing the quantity and the strength of acidity of zeolites. It was revealed that HY, USY and USYH behaved quite differently in this respect. Their Bronsted acid strength are of three different levels and the Lewis acid strength of USYH is unexpectedly high. A better corresponding relation between the cracking activity for n-decane and Bronsted acid strength is found. These three zeolites samples, in acidity, may be taken as representatives of zeolites investigated.

Discussion on the effect of ultrastable treatment, the properties of cations and subsequent NH_4^+ exchange on the stability of zeolites, the nature and accessibility of the acid sites was given. (Paper received 18 Sep 84.)

REFERENCES

- (1) Scherzer, J., Bass, J. L. & Hunter, F. D., *J. Phys. Chem.*, **79**, 1194 (1975); *J. Catal.*, **54**, 405 (1976); *J. Catal.*, **46**, 100 (1977).
- (2) 余勋勤, 刘兴云, 李宜文, 石油炼制, No. 5, 10 (1982); 催化学报, **1**, 288 (1980).
- (3) 张盈珍, 尹桂林等, 石油化工, **14**, 354 (1985).
- (4) Ward, J. W. in "Zeolite Chemistry and Catalysis", (Ed. Rabo, J. A.), ACS, Washington, Chapt. 3, 1976.
- (5) Barthomeuf, D. & Beaumont, R., *J. Catal.*, **30**, 288 (1973).
- (6) Dempsey, E., *ibid.*, **33**, 497 (1974).
- (7) Barthomeuf, D., *Reprints* (Div. Petrol. Chem., Amer. Chem. Soc.), **23**, 875 (1983).
- (8) Datka, J., *J. Chem. Soc., Faraday Trans. I*, **77**, 2877 (1981).

DISTRIBUTION OF THE BIVALENT NICKEL ION IN ZSM-5 MOLECULAR SIEVE

Beijing CUIHUA XUEBAO [JOURNAL OF CATALYSIS] in Chinese Vol 7, No 1, Mar 86
pp 46-53

[English abstract of article by Liu Zhenyi [0491 2182 5030], et al., of Department of Chemistry, Beijing University]

[Text] The catalytic behavior of ZSM-5 zeolite can be modified by both physical and chemical methods. Structural parameters of three-dimensional channel of ZSM-5 zeolite can be changed by physical method because of its structural flexibility, so its catalytic behavior is also changed. To elucidate the mechanism of the chemical modification, the structure of ZSM-5 zeolite after being exchanged with pressurized nickel was determined by polycrystal X-ray diffraction. It has been discovered that there are two positions of bivalent nickel ion outside the framework of ZSM-5 zeolite. One is that $\text{Ni}^{2+}(1)$ is located nearby the central point of the median line in the hexacycle facing the cavity of two channels and deviates to ca. $1.5\text{\AA}$ from the wall of the channel. $\text{Ni}^{2+}(1)$ in such position has a direct influence upon the nearby electric charge distribution in the active center of ZSM-5 zeolite even though it is not inside the channel. Another is that $\text{Ni}^{2+}(2)$ is located in parallel to (100) direction of "Z" form channel and deviates to ca. $1.6\text{\AA}$ from the center of decacycle. The existence of Ni^{2+} changes the effective gap in the opening of "Z" form channel; and, $\text{Ni}^{2+}(2)$ itself can be in contact with the reactants entered into the channel of zeolite and participates catalysis. (Paper received 27 Dec 84.)

REFERENCES

- (1) Chen, N. Y. & Garwood, W. E., *J. Catal.*, **52**, 453(1978).
- (2) 张毓静等, 石油学报(石油加工), **1**(1), 41(1985).
- (3) Chen, N. Y., Kaeding, W. W. & Dwyer, F. G., *J. Amer. Chem. Soc.*, **101**, 6783(1979).
- (4) 周日新等, 石油化工, **11**, 781(1982).
- (5) 吴指南等, 石油化工, **12**, 196(1983).
- (6) Olson, D. H. et al., *J. Phys. Chem.*, **85**, 2238(1981).
- (7) 于勤等, 石油学报, **3**(3), 83(1982).
- (8) Albinati, A. & Willis, B. T. M., *J. Appl. Cryst.*, **15**, 361(1982).

THE PROPERTIES OF OXYGEN SPECIES ON THE SURFACE OF V_2O_5/SiO_2 CATALYST

Beijing CUIHUA XUEBAO [JOURNAL OF CATALYSIS] in Chinese Vol 7, No 1, Mar 86
pp 82-86

[English abstract of article by Zheng Xiaoming [6774 1420 2494], et al., of
Department of Chemistry, Hangzhou University]

[Text] The TPD spectra of the surface oxygen of V_2O_5/SiO_2 catalyst have been
obtained by using the high sensitive TPD-MS determination.

TPD spectra show obviously that the surface oxygen of V_2O_5/SiO_2 can be divided
into three groups which possess different energies. The first group of surface
oxygen is desorbed at 100-150°C, the second group is desorbed at 400-600°C, and
the third at above 600°C. They correspond probably to the desorption of O_2, O^-
and O^{2-} respectively in accordance with the ESR results. The area S_1 of the
first peak is no more than 5-10 percent of the total peak area (S_1+S_2) of the
catalyst, therefore, O^- is the main form of active oxygen on V_2O_5/SiO_2 catalyst.
Dealing with the peak temperatures at different heating rates, the kinetic
parameters of desorption species are obtained. The desorption activation energy
of the first peak is 7.83 Kcal/mol, it concurs with the characteristic of weak-
adsorbed O_2 . The apparent activation energy of the second peak is as high as
154 Kcal/mol, because the desorption step has to break two bonds of $V-O^-$, and
to overcome the big repelling force between two negative charges during the
collisions of two $M-O^-$. (Paper received 1 Jul 85.)

REFERENCES

- (1) Lunford, J. H., *Adv. Catal.*, **22**, 285(1972).
- (2) Lunford, J. H., *Catal. Rev.-Sci. Eng.*, **8**, 195(1973).
- (3) 田部治三等, "金属氧化物和复合氧化物", 讲谈社, 东京, p. 125, 333, 1978.
- (4) Sechtler, W. M. H. et al., *Catal. Rev.-Sci. Eng.*, **23**, 127(1981).
- (5) Cho, M. & Teach, A. J., *Adv. Catal.*, **31**, 77(1983).
- (6) 岩本正和, 触媒(日), **36** (1), 30(1984).
- (7) Shveta, V. A. et al., *J. Catal.*, **11**, 378(1968).
- (8) Tarama, K. et al., *Bull. Chem. Soc. Japan*, **42**, 1161(1969).
- (9) Shveta, V. A., Kazanaky, V. B. et al., *J. Catal.*, **25**, 123(1972).
- (10) Yoshida, S. et al., *Bull. Chem. Soc. Japan*, **47**, 1844(1974).
- (11) Yoshida, S. et al., "Proceedings of the 8th International Congress on Catalysis", (Ed. Hightower
J. W.), North-Holland, Amsterdam, p. 1049, 1972.
- (12) Iwamoto, M. et al., *J. Phys. Chem.*, **82**, 2864(1978).
- (13) 王吉祥, 谢俊机, 催化学报, **1**, 229(1980).
- (14) 邢超五, 郑小明, 金松寿, "集团结构通理论文集", 第1卷, 第53页, 1984.

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Chemistry

DETERMINATING THE ACTIVITY OF SOLID CATALYST S101 TYPE SULFURIC VANADIUM CATALYST BY USING CD-2 TYPE INTERNAL RECYCLE GRADIENTLESS REACTOR

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATIONAL SCIENCE EDITION)] in Chinese No 1, 1986 pp 78-83

[English abstract of article by Tan Liye [3389 4539 2814]]

[Text] The principle and method for determinating solid catalyst activity by using internal recycle gradientless reactor have been discussed in this paper. The data of activity of S101 type sulfuric vanadium catalyst had been determined. Thus correlated with tubular reactor method and recycle gradientless reactor method; and predicating the functions of pilot-plant reactor.

REFERENCES

- [1] 陈福英, 石油化工, 7 (1978), 290
- [2] 谭立业, 石油炼制, 3 (1979), 14
- [3] 谭立业、唐玉华, 四川化工, 2 (1982), 40
- [4] 陈甘棠、梁玉衡, 化学反应技术基础, 科学出版社, 1981
- [5] 谭立业、唐玉华、罗开统*, 应用 CD-2 型内循环无梯度反应器在 S101 型钒催化剂上研究 SO_2 催化氧化动力学, 1984

CHROMATOGRAPHIC SEPARATION OF PLATINUM METALS IN TWICE DEVELOPMENT

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATIONAL SCIENCE EDITION)] in Chinese No 1, 1986 pp 84-93

[English abstract of article by Luo Liangqiong [5012 5328 8825] and Zhang Chang [1728 1281]]

[Text] The chromatographic behaviour of platinum, palladium, rhodium, ruthenium, osmium iridium, gold, copper, cobalt and nickel on paper strips treated with N_{235} and N_{263} and eluted with HCl , HNO_3 and HNO_3-HCl mixed acid was investigated. On this basis, a two stepwise chromatographic method was proposed to separate the mixture of platinum metals, gold, copper, cobalt and nickel. Strip with stationary phase N_{263} was first developed with a mobile phase 4N HCl to separate cobalt, copper, nickel and rhodium, then a second mobile phase of 4N $HNO_3-2N HCl$ was used to separate gold and five remained platinum metals. The method has successfully been used to separate and detect ten metals mentioned above.

REFERENCES

- [1] 楊正偉、馬忠良、羅良琮、鉑系元素的反相紙色層 (1979年, 全國無機化學論文報告會論文)
- [2] 羅良琮、趙文玉、盧勇、林、健的萃取分配和紙色層 (1979年, 全國無機化學論文報告會論文)
- [3] S. Przeszlakowski et al, *Talanta*, **26** (1979), 1125
- [4] S. I. Ginzburg et al, *Analytical Chemistry of Platinum Metals*, John Willy & Sons, 1975
- [5] F. E. Beamish et al, *Recent Advances in the Analytical Chemistry of the Noble Metals*, 1966
- [6] T. Braun et al, *Extraction Chromatography*, 1973
- [7] 高家隆等, 化學學報 **29** (1963), 421
- [8] 劉萬一, 分析化學 **9** (1981), 51-3

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CSO: 4009/1059

AXIALLY DISSYMMETRIC BIARYLS

2. THE SYNTHESIS OF (+)- and (-)-10,10'-DIHYDROXY-9,9' -BIPHENANTHRYL.

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 86 pp 18-24

[English abstract of article by Xie Songkai [6200 7313 0418], et al.]

[Text] Study of axially dissymmetric biaryls has recently been revived. Most of the work, however, was focused in derivatives of 1,1' -binaphthyl in terms of their syntheses and application to chiral recognition and various asymmetric syntheses^[1]. We have been interested in finding synthesis and stereochemistry of higher analog of biaryls. In this article, we demonstrate a novel synthetic approach to both enantiomers of 10,10'-dihydroxy-9,9'-biphenanthryl [(1)- and (+)-6]^[5] was demonstrated. (Paper received Nov 85.)

REFERENCES

- (1) (a). Cram, D.J., Trueblood, K.N., in *Topics in Current Chemistry*, 98,(1981), 43
(b). Cram, D.J., Cram, J.M., *Acc. Chem. Res.*, 11(1978), 8.
(c). Noyori, R., Tomino, T., Tanimoto, Y., Nishizawa, M., *J. Am. Chem. Soc.*, 106(1984), 6709, 6717.
(d). Miyano, S., Handa, S., Shimizu, K., Tagami, K., Hashimoto, H., *Bull. Chem. Soc. Jpn.*, 57(1984); 1943.
(e). Mazaleyrat, J. -P., Cram, D.J., *J. Am. Chem. Soc.*, 103(1981), 4585.
(f). Olivero, A.G., Weidmann, B., Seebach, D., *Helv. Chim. Acta.*, 64(1981), 2485.
(g). Miyashita, A., Takaya, H., Souchi, T., Noyori, R., *Tetrahedron*, 40(1984), 1245.
- (2) (a). Badger, G.M., Drewer, R.J., Lewis, G.E., *J. Chem. Soc.*, 1962, 4268.
(b). Yamada, S., Akimoto, H., *Tetrahedron Lett.*, 1968, 3967.
- (3) Review see: Gschwend, H.W., Rodriguez, H.R., *Org. Reactns.*, 28(1980), 61.
- (4) 许遵乐、黄文洪、邵亮、谢颂凯, 有机化学, 1985, 475.
- (5) Yamamoto, K., Tukushima, H., Okamoto, Y., Hatada, K., Nakazaki, M., *J. Chem. Soc., Chem. Commun.*, 1984, 1111.
- (6) Horning, E.C., 有机合成, 中译本, 1955, 3, 82.
- (7) Bacon, R.G.K., Rennison, S.C., *Chem. & Ind.*, 1966, 812.
- (8) Jolly, W.L., 无机合成, 中译本, 11(1975), 72.

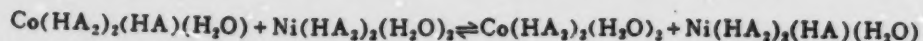
A STUDY OF THE SELECTIVITY OF SOLVENT EXTRACTION OF COBALT(II) AND NICKEL(II)
AS THE MOLECULAR STRUCTURE OF THE EXTRACTABLE CHELATES

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM
UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 86 pp 37-43

[English abstract of article by Yang Xueqiang [2799 1331 1730], et al.]

[Text] The composition and structure of extractable chelates and the reaction mechanism of extraction in the solvent extraction systems of cobalt(II) and nickel-(II) with commercial P_{204} di(2-ethylhexyl)phosphoric acid and P_{507} di(2-ethylhexyl)phosphonic acid were investigated.

The following substituted reaction was first found in the organic phase systems of cobalt(II) and nickel(II) with di(2-ethylhexyl)phosphoric acid.



It has been proved that the selectivity of solvent extraction of cobalt(II) and nickel(II) depended remarkably on the molecular structure of the extractable chelates. (Paper received Nov 84.)

REFERENCES

- [1] 高自立等, 有色金属, 1984, 1, 42.
- [2] 沈静兰等, 有色金属, 1983, 2, 47.
- [3] J.S.Preston, *Hydrometallurgy*, 9(1982), 2, 115-133.
- [4] T.Sato et al., *J.Inorg. Nucl. Chem.*, 34(1972), 3721.
- [5] J.E.Barnes et al. *J.Inorg. Nucl. Chem.*, 38(1976), 1065-1067.
- [6] 陈金榜等, 高等学校化学学报, 1983, 3, 281.
- [7] 北京矿冶研究总院等, 有色金属, 1981, 1, 25.

AN INVESTIGATION INTO ADDITIVE-TYPE DIESEL ENGINE FUEL AND COMBUSTION

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 2, Apr 86 pp 104-110

[English abstract of article by Xie Shiwen [6043 0013 2429] of Internal Combustion Engine Research Institute]

[Text] The effect of the additive-type fuel on the expansion of light fuel source and the improvement of the combustion of heavy fuel in high speed diesel engines were studied.

The selectivity of additives and the relationship between the diesel performance and values of l , ψ , and φ of the additive-type fuel were explored. (Paper received 4 Jun 85.)

REFERENCES

- [1] J. E. Foulger, Chemical Additives as Part of Integrated Fuel Management, MER, 1981—9.
- [2] Scandinavian Operators Claim Good Results with Clean Power Additive, Motor Ship, 62—734, 1981—9.
- [3] W. R. メイ, 松本安弘, 加藤裕之, 《ガスタービン添加剤》, [日] 燃料及び燃焼, 昭57年5月(1982), P17—22.
- [4] G. Hanter, J. Scholl, et al, The Effects of Fuels on Diesel Oxidation Catalyst Performace and the Physical, Chemical, and Biological character of Diesel Particulate Emissions, SAE, Trans, 811192.
- [5] 《ディーゼル機関の微粒子の焼却を促進する塩化物》, 海外技術ハイライド, 1982. 10, Vol16, No7.
- [6] 絵畑义南, 《触媒にするディーゼル機関のススの酸化促進》, モータビクル, 1982.No9, P48—51.
- [7] 解世文, 《车用柴油机燃料燃烧性能的非动力研究》, 汽车技术, 1984. No11, P37—41.
- [8] 解世文, 《柴油机燃料燃烧完全性的氧弹研究》, CICS会议论文 No 844072. 1981.1).

TWO-DIMENSIONAL MATHEMATICAL MODELING FOR THE FIXED-BED REACTOR OF ETHYLBENZENE DEHYDROGENATION

Lanzhou HECHENG XIANGJIAO GONGYE [SYNTHETIC RUBBER INDUSTRY] in Chinese Vol 9, No 3, May 86 pp 157-163

[English abstract of article by Tong Zemin [0157 3419 3046] of Department of Chemical Technology, Beijing Petrochemical College]

[Text] A two-dimensional mathematical model was proposed for the design of ethylbenzene dehydrogenation on fixed-bed reactor. The reactor was packed with Chinese-made Type-315 catalyst. Parameters were estimated based on a 2000 tons per year industrial reactor. The calculated outlet temperature and conversion were in good agreement with the data measured from industrial reactor. The calculated axial or radial temperature distribution, and conversion distribution were shown in diagrams. The biggest difference between radial temperature in the same axial position was 51°C. (Paper received 4 Nov 85.)

REFERENCES

- (1) 蔡世干, 合成橡胶工业, 8(3), 184 (1983).
- (2) 陈甘棠主编, "化学反应工程", 化学工业出版社, 234 (1981).
- (3) 王化淳、杨春生, 化学工程, (1), 33 (1985).
- (4) 北京燕山石化公司向阳化工厂, 内部资料.
- (5) 赵中琦等, 催化学报, 6(2), 107 (1983).
- (6) 天津大学化学工程教研室, "化学工程", 第四册, 201 (1976).
- (7) Howard, F. Rase, "Chemical Reactor Design for Process Plants", Vol. II, 139 (1977).
- (8) 兰州化学工业公司设计院编, 石油化工技术参考资料 (33), "石油化工工业炉设计".
- (9) Jenson, V.G., Jeffreys, G.V., "Mathematical Methods in Chemical Engineering", 2nd Ed., (1977).

STUDY OF THE REACTORS FOR THE THERMAL BULK POLYMERIZATION OF STYRENE

II. THE EFFECT OF MICROMIXING OF POLYMERIZATION

Lanzhou HECHENG XIANGJIAO GONGYE [SYNTHETIC RUBBER INDUSTRY] in Chinese Vol 9, No 3, May 86 pp 163-167

[English abstract of article by Feng Dibai [7458 0966 2672] of Lanzhou Petrochemical Engineering Design Institute of SINOPEC]

[Text] The effect of micromixing on polymerization reaction speed and product quality of thermal bulk polymerization of styrene was studied with mathematical model of micromixing for polymerization reactors developed early. The results show that microsegregation speeds up the reaction and makes the reaction speed approach to that of piston flow reactor. The average molecular weight and its distribution of polystyrene obtained in microsegregation reactor are also between those of piston flow and maximum micromixing reactors. (Paper received 20 Sep 85.)

REFERENCES

- (1) 冯地柏, 合成橡胶工业, 7(1), 13 (1984)。
- (2) 计其达, “聚合过程及设备”, 化学工业出版社, 88-89 (1981)。
- (3) Hui, A. W., et al., J. Appl. Poly. Sci., 18 (3), 749 (1972)。
- (4) 冯康, 百科知识, (5), 43 (1985)。
- (5) 冯地柏, 合成橡胶工业, 8(4), 240 (1985)。
- (6) Danckwerts, P. V., “The Effect of Incomplete Mixing on Homogeneous Reactions”, Chemical Reaction Engineering, 12th Meeting Europ. Fed. Chem. Engng. Amsterdam, (1957)。
- (7) Zwietering, T. H. N., Chem. Engng. Sci., 11(1), 1 (1959)。
- (8) Tadmor, Z., Biesenberger, J. A., I & EC Fund., 5(3), 336 (1966)。
- (9) Vollmert, B. 著, 孙以实译, “聚合物化学” (上), 化学工业出版社, 99 (1980)。

MICROKINETIC STUDY OF BUTADIENE POLYMERIZATION WITH $\text{MoCl}_4-(i\text{-Bu})_2\text{AlO}-\text{CH}_2$ CATALYST SYSTEM

1. RATE EQUATION OF POLYMERIZATION AND DETERMINATION OF KINETIC PARAMETERS

Lanzhou HECHENG XIANGJIAO GONGYE [SYNTHETIC RUBBER INDUSTRY] in Chinese Vol 9, No 3, May 86 pp 179-183

[English abstract of article by Yang Yuwei [2799 3768 0251], et al., of Department of Polymer Engineering, Qingdao Institute of Chemical Technology]

[Text] The kinetic behavior of butadiene (Bd) polymerization with

$\text{MoCl}_4-(i\text{-Bu})_2\text{AlO}-\text{CH}_2$ catalyst was studied. The reaction order of monomer and catalyst was determined. The kinetic parameters, the efficiency of catalyst was determined. The kinetic parameters, the efficiency of catalyst, the concentration and the average life period of active center etc within the temperature range of 30-70°C were also obtained. The experimental results show that the rate of polymerization is first order with respect to both the concentrations of monomer and MoCl_4 . The rate equation of polymerization can be expressed as follows:

$$-d[\text{Bd}]/dt = k_p a[\text{MoCl}_4][\text{Bd}]$$

The total activation energy for butadiene polymerization with

$\text{MoCl}_4-(i\text{-Bu})_2\text{AlO}-\text{CH}_2$ catalyst system is 17.4 kcal/mol, and the catalyst efficiency is found to be about 1.5 percent. The average life period of active center reduces with the rise of polymerization temperature. (Paper received 27 Jul 85.)

REFERENCES

- (1) 倪少儒、高锦国、唐学明, 高分子通讯, (4), 241, (5), 336 (1983)。
- (2) 杨玉伟、唐学明, 四价钼催化体系合成高乙烯基聚丁二烯的研究, 待发表。
- (3) 杨玉伟、鞠远波、唐学明, 合成橡胶工业, 8 (5), 330 (1985)。
- (4) 杨玉伟、李 迎、辛浩波、唐学明, 合成橡胶工业, 9(2), 101 (1986)。
- (5) 竹内安正, 日本橡胶协会志 (日文), (8), 43 (1979)。
- (6) 健谷勋, 石油和石油化学 (日文), (9), 100 (1969)。
- (7) 于广谦, “稀土催化合成橡胶文集”, 科学出版社, 49 (1980)。

A NEW CROSSLINKING SYSTEM FOR MERCAPTAN-TERMINATED POLY(BUTADIENE-ACRYLONITRILE) LIQUID RUBBER

Lanzhou HECHENG XIANGJIAO GONGYE [SYNTHETIC RUBBER INDUSTRY] in Chinese Vol 9, No 3, May 86 pp 196-201

[English abstract of article by Jia Demin [6328 1795 3046], et al., of Materials Science Research Institute, South China Institute of Technology, Guangzhou]

[Text] Epoxy resin (Epon 828)/2-ethyl-4-methylimidazole (EMI-24) was used as a new crosslinking system for the mercaptan-terminated poly(butadiene-acrylonitrile) liquid rubber (MTBN). Kinetics of the crosslinking reaction investigated by means of JSR-curelasterometer. The curing formulations, curing conditions and mechanical properties of cured MTBN were also investigated. The results show that this crosslinking system is effective for the crosslinking of MTBN. In contrast to Epon 828/DMP-30 (2,4,6-tri, dimethylaminomethyl phenol), the conventional crosslinking system, the new one has faster curing speed at moderate curing temperatures and the cured products have better mechanical properties and longer pot life, etc. (Paper received 8 Jun 85.)

REFERENCES

- (1) Drake, R.S., McCarthy, W.J., Rubber World, 159(10), 121 (1968).
- (2) 沈诗能、王孟钟, 合成橡胶工业, 7(4), 287 (1984).
- (3) 长谷部嘉彦、明石直光, 日本橡胶协会志(日文), 41(10), 879 (1968).
- (4) 梅野昂, 日本橡胶协会志(日文), 41(10), 863 (1968).
- (5) 日本橡胶协会志(日文), 50(8), 830 (1977).
- (6) Dea love, T.J., J. Appl. Polym. Sci., 14, 1615 (1970).

EFFECT OF CURING AGENTS ON THERMAL-OXIDATIVE AGING PROPERTIES AND DAMPING COEFFICIENT OF EPDM-CIIR RUBBER BLENDS

Lanzhou HECHENG XIANGJIAO GONGYE [SYNTHETIC RUBBER INDUSTRY] in Chinese Vol 9, No 3, May 86 pp 202-205

[English abstract of article by Zhang Fenyu [1728 5358 3768], et al., of Changchun Institute of Applied Chemistry, Academia Sinica]

[Text] The EPDM-CIIR rubber blends were vulcanized with S-DCP (sulphur-dicumyl peroxide), GM-S (p-benzoquinone dioxime-sulphur) and 201 resin (brominated polymethyl phenol resin), respectively. Some properties and $\tan \delta$ values of the vulcanizates were measured by rheovibron viscoelastomer, tensile tester and TDA. The results show that the rubber blend vulcanized with 201 resin has the best thermal-oxidation resistance and the change of the $\tan \delta$ value is the least of all the vulcanizates. The activation energies have been calculated based on the relationship of $\log \tan \delta - T^{-1}$, and the values are 1.50, 0.82 and 0.40 kcal/mol, respectively for the three types of vulcanizates. (Paper received 4 May 85.)

REFERENCES

- (1) 阮桂海, "丁基橡胶应用工艺", 化学工业出版社, (1980)。
- (2) W.雷夫曼著, 王梦蛟译 "橡胶硫化与硫化配合剂", 石油化学工业出版社, (1975)。
- (3) 何曼君、陈维学、董西侠, "高分子物理", 复旦大学出版社, (1982)。
- (4) Edwards, D. C., Rubb. Chem. Technol., 39, 581 (1966)。
- (5) 井本睦等, 日本橡胶协会志(日文), 41, 583 (1968)。
- (6) 横津佳代子, 日本橡胶协会志(日文), 41, 96 (1968)。
- (7) Studebaker, M.L and Beatty, J.R., Rubb. Chem. Technol., 47, 803 (1974)。

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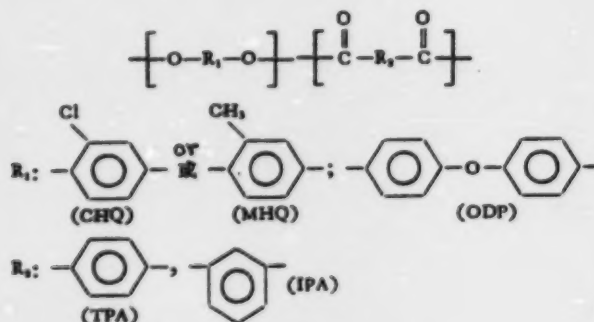
THERMOTROPIC LIQUID CRYSTALLINE POLYMERS

-AROMATIC COPOLYESTERS CONTAINING MONOSUBSTITUTED BENZENE RINGS AND KINKING COMPONENTS

Beijing GAOFENZI TONGXUN [POLYMER COMMUNICATIONS] in Chinese No 3, Jun 86 pp 181-187

[English abstract of article by Xie Ping [6200 5493], et al., of Institute of Chemistry, Academia Sinica, Beijing]

[Text] The series of copolyesters were prepared from chloro-hydroquinone or methyl-hydroquinone, terephthalic acid and two kinds of comonomers, which could provide kinking and bending in chain: Oxy-4,4'-diphenol and isophthalic acid. The four-components copolyesters in certain range of compositions have low melting temperature, steady mesophase in a broad temperature range and fiber-forming tendency. Focuses on the relations of molecular composition-transitions-liquid crystallinity and fiber-forming tendency, and the morphologic features of mesophase. The general structure is as follows:



(Paper received 5 Mar 84.)

REFERENCES

- [1] 谢岸、陆道惠、黄瑞、郑树洪、宝净生, 高分子通讯, 1985, (4), 269.
- [2] Kleinschuster, J. J., Fletcher, T. C., U. S. P. 4,066, 620, 1978.
- [3] Lenz, R. W. and J. -I. Jin. *Macromol.*, 1981, 14, 1405-1411.
- [4] Bosch, A. Ten, Maissa, P., Sixou, P., *Polym. Pre.*, 1983, 24, 246.
- [5] Motoharu Fujii, Kyosuke Nagasaka, Jiroshimada and Hiromi Yamakawa, *Macromol.*, 1983, 16, 1613-1623.
- [6] Vittorio Frosini, Augusto Marchetti, Silvano de petris, *Makromol. Chem., Rapid Commun.*, 1982, 3, 795-801.
- [7] Janusz Grebowicz and bernhard Wunderlich, *J. Polym. Sci. Phys.*, 1983, 21, 141-150.
- [8] Bata, L. "ADVANCES IN LIQUID CRYSTAL RESEARCH AND APPLICATIONS" (Proc. Third. Liq. Crys. conf.), 1979, 943.

DETERMINATION OF PHOSPHORUS AND FLUORINE IN POLYMERS AND ORGANIC COMPOUNDS WITH Nd^{3+}

Beijing GAOFENZI TONGXUN [POLYMER COMMUNICATIONS] in Chinese No 3, Jun 86 pp 203-207

[English abstract of article by Xie Zhengqiu [6200 2973 4428] of Department of Chemistry, Wuhan University, Wuhan]

[Text] Procedures are developed for the determination of fluorine and phosphorus in polymers and organic compounds by titration with $\text{Nd}(\text{NO}_3)_3$ -EDTA

after decomposing the sample by O-flask. An amount of sample corresponding to approximately 1 mg of fluorine is decomposed and absorbed in an O-flask containing an excess of 0.01M Nd^{3+} (NO_3)₃. The absorbing liquid is boiled for 3 minutes. After being allowed to cool, a pH=5.5 buffer is added. In the presence of xylenol orange, the mixture is titrated with 0.01M EDTA. The procedure for determining phosphorus is the same as described above, but precipitation reaction of NdPO_4 is carried out in pH 5.5 after eliminating CO_2 . If sample contains F and P, PO_4^{3-} in the solution containing F^- can be determined after eliminating F^- by adding HNO_3 and concentrating solution to dryness, and the percentage of F can be found after determining the total content of F and P. Determination procedure of total content is the same as F^- , but buffer is added while the mixture is hot. The maximum error of determining P is ± 0.20 percent and F is ± 0.30 percent except high fluorine or fully fluorinated compounds which give values approximately 0.50 percent lower than calculation. (Paper received 30 Mar 84.)

REFERENCES

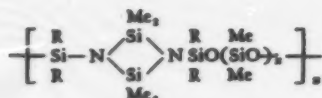
- [1] 能代 诚, 樋田 富雄, 分析化学(日), 1977, 26, 721.
- [2] Осадчий В. Д., Маклакова А. В., Заводск. Лаборатория, 1977, 43, 269.
- [3] Naga, A., Kobayashi, N., Hasegawa, K., Honba, K. and Baba, S., *Microchem. J.*, 1975, 20, 440.
- [4] 穂積啓一郎、秋元直茂, 分析化学(日), 1971, 20, 467.
- [5] Friese, H. J., *Mikrochim. Acta*, 1981, 1, 265.
- [6] 陈耀祖、杜稼华, 有机微量定量分析, 科学出版社, 1978, 214.
- [7] Light, T. S., Manion, R. F., *Anal. Chem.*, 1969, 41, 107.
- [8] 王昌益、和海青, 高分子通讯, 1980, (5), 309.
- [9] Hassan, S. S. M., *Mikrochim. Acta*, 1974, 889.
- [10] 刘惠英、何云祯、丁自荣、曾昭抡, 化学学报(增刊), 1981, 153.
- [11] Цыганова М. Ф., Новикова К. Ф., *ЖАХ*, 1969, 24(2), 272.
- [12] 云南省化工研究所有机微量分析小组, 分析化学, 1978, 4(6), 440.
- [13] Püschel, R. und Wittmann, H., *Mikrochim. Acta*, 1960, 670.
- [14] Hunter, T. L., *Anal. Chim. Acta*, 1966, 35, 398.
- [15] Selig, W. Z., *Anal. Chem.*, 1969, 247, 294.
- [16] Bennewitz, R. und Tänzer, I., *Mikrochim. Acta*, 1959, 835.
- [17] Olson, E. C. and Shaw, S. R., *Microchem. J.*, 1961, 5, 101.
- [18] Lévy, R. und Debal, E., *Mikrochim. Acta*, 1962, 224.
- [19] 谢正秋、赵明煥、段九菊, 高等学校化学学报, 1983, 4(5), 646.

THERMAL STABILITIES OF SILICONE GUMS CONTAINING CYCLODISILAZANE IN THE BACKBONE

Beijing GAOFENZI TONGXUN [POLYMER COMMUNICATIONS] in Chinese No 3, Jun 86
pp 208-213

[English abstract of article by Li Qishan [2621 0366 1472] and Xie Zemin [6200 2344 3046] of Institute of Chemistry, Academia Sinica, Beijing]

[Text] The thermal stabilities of silicone gums containing cyclodisilazane,



(SCD), R=Me, Ph, Were studied in comparison with methyl and phenyl silicone gum by the method of TGA. IGA. GC. and GC-MS. The initial temperature of the weight loss of SCD is 150-200°C higher than that of methyl silicone gum, the weight loss is 10-20 times less than that of methyl as well as phenyl silicone polymer. Based on both the GTA and the IGA data, the presence of cyclodisilazane in SCD enhances the resistance of the main chain to degradation and the weight loss remains almost the same as the number (x) of Me₂SiO groups in SCD changes. Outstanding stability of this material makes them to be used potentially as high-temperature elastomers. According to analysis of the decomposed products a two steps mechanism of degradation is proposed. (Paper received 3 Apr 84.)

REFERENCES

- [1] 谢择民、李其山、王金亭、谢祖寿, 高分子通讯, 1979, (4), 216.
- [2] Александрова, Ю. А. и Др., Высокомолекулярное Соединение, 1988, 10, 1078.
- [3] Thomas, T. H., Hendrick, T. C., J. Polym. Sci. A-2 1969, 7, 537.
- [4] Knollmueller, K. O., Scott, R. N., J. Polym. Sci. A-1, 1971, 9, 1071.
- [5] Roller, M. N., Gillham, T. K., J. Appl. Polym. Sci., 1973, 17, 2141.
- [6] 李二成、谢择民、王金亭、徐广智、叶朝辉, 波谱学杂志, 1984, 1(4), 353.

/7358

CSO: 4009/1072

MULTIVARIATE GENERALIZED SPLINE APPROXIMATION TO SCATTERED DATA WITH CONTINUOUS BOUNDARY CONDITIONS THROUGHOUT A RECTANGLE

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 86 pp 79-86

[English abstract of article by Guan Lutai [7070 1462 3141]]

[Text] For multivariate generalized spline interpolation to scattered data and continuous boundary conditions, a suitable generalized blending spline function space is constructed. Existence, uniqueness, characteristics and the structure of the solution in such a space are established. The method can easily be carried out in a computer. (Paper received Dec 84.)

REFERENCES

- [1] Li Yuesheng(李岳生), CAT^{*} 55(1984), *Center for Approximation Theory*, Texas A&M University.
- [2] Birkhoff, G & de Boor, *Approximation of Functions*, H.L. Garabedian ed., Elsevier, Amsterdam, 1965, 164-190.
- [3] Birkhoff, G & H.L. Garabedian, *J. Math. Phys.*, 39(1960), 258-268.
- [4] Schumaker, L.L., *Approximation Theory I*, ed. by G.G. Lorentz, C. Chui & L.L. Schumaker, Academic Press, N.Y. 1976, 203-268.
- [5] Duchon, J., *Rpt.* 27, Univ. of Grenoble, 1976.
- [6] Meinguet, J., *Polynomial and Spline Approximation*, ed. by Badrin Sahney, Canada, 1978.
- [7] Dyn, L. & D. Levin, *R.A.I.R.O. Numerical Analysis*, 16(1982), 3, 201-209.
- [8] Arthur, D.W., *J. Approximation Theory*, 12(1974), 396-411.
- [9] Ritter, K., *Approximation with Special Emphasis on Spline Functions*, ed. by I.J. Schoenberg, Acad. Press, N.Y., 1969, 185-222.
- [10] Mansfield, L.E., *SIAM J. Numer. Anal.*, 8(1971), 1.
- [11] Laurent, P.J., *Approximation et Optimisation*, Hermann, Paris, 1972.
- [12] 关履泰, 应用科学学报, 1983, 3, 193-201.
- [13] 关履泰, 高等学校计算数学学报, 1982, 3, 268-278.
- [14] M. 阿佛里耳, 非线性规划(下), 上海科学技术出版社, 1980.
- [15] Fletcher, R., *J. Inst. Math. Appl.*, 7(1971), 76-91.

SMOOTH BIHARMONIC SPLINES ON CIRCULAR DOMAIN

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 86 pp 87-92

[English abstract of article by Lie Luoluo [7812 5012 5012]]

[Text] Two types of smooth biharmonic splines defined on circular domain are introduced. Characteristic conditions, existence and uniqueness of a solution are given. Smooth parameter is selected by iterative method and the solution can be obtained by solving a sequence of systems of linear algebraic equations which possess non-singular symmetric coefficient matrices. (Paper received Nov 84.)

REFERENCES

- 〔1〕 钱伟长、叶开源, 弹性力学, 科学出版社, 1980.
- 〔2〕 黄义, 弹性力学基础及有限单元法, 冶金工业出版社, 1983.
- 〔3〕 A. H. 吉洪诺夫, A. A. 萨马尔斯基, 数学物理方程, 人民教育出版社, 1963.
- 〔4〕 G. I. Marchuk, *Methods of Numerical Mathematics*, Springer-Verlag. New York, 1982.

/7358

CSO: 4009/1074

SOFTWARE FOR SECTION-LINE DRAFTING OF COMPLICATED MECHANICAL FIGURES

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 2, Apr 86 pp 135-138

[English abstract of article by Liu Chengfang [0491 6134 2455], et al., of Department of Mechanical Engineering]

[Text] This paper proposes a method of designing the software for the section-line drafting in computer aided design and illustrates the engineering feasibility of drawing complicated mechanical figures with the shortest straight lines as well as the advantage of drafting speed.

This paper also presents a method model distinction in place of the conventional method of cutting figures to solve problems of the leap of the drafting-pen in the process of drafting and the section-line drafting of complicated objects with an open space in the center. (Paper received 6 Feb 85.)

REFERENCES

- [1] 北京工业大学, 微机应用研究室《微型计算机绘图系统》1983.10
- [2] 范鸿玉、张莹《最优化技术基础》清华大学出版社, 1982
- [3] 金德安等《剖面线程序》浙江大学学报, 1981. 9.
- [4] 《DXY-800》PLOTTER MANUAL 1983
- [5] 《SR-6602 PLOTTER INSTRUCTION MANUAL》1983

/7358

CSO: 4009/1058

AI CONTROL AND ITS APPLICATION IN TEMPERATURE-CONTROLLING SYSTEM

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 1-5

[English abstract of article by Tu Xiangchu [3205 6272 0443] et al., of Beijing Polytechnic University]

[Text] A new approach to AI control is described, which possesses the merits of fuzzy control as well as that of conventional control and can carry out a series of experts' functions by means of an AI software. Results of laboratory tests and operations of a practical control system show that the qualities of the AI temperature-controller is excellent. A temperature-controlling system using this AI controller realizes a best quality of control: the temperature stability obtained is better than 0.0004K/h in the measuring range 13~120K. (Paper received Jan 85, finalized Nov 85.)

REFERENCES

- [1] 汪培庄:《模糊集合论及其应用》,上海科学技术出版社,第1版,p. 2, 1983.
- [2] 涂序彦:智能控制浅谈,自动化, No. 3, p. 6, 1984.
- [3] L. A. Zadeh: Fuzzy Sets, The Concept of a Linguistic Variable and Its Application to Approximate Reasoning, [陈国权译:模糊集合、语言变量及模糊逻辑,科学出版社,第1版,p. 155 (附录I), 1982年].
- [4] Tu Xiangchu: A simple and effective set-point regulator of artificial intelligence type, BUSEFAL, No. 15, pp. 105—116, 1983.
- [5] 涂序彦: Fuzzy 控制器在定值调节中的新应用途径,模糊数学, No. 2, pp. 65—72, 1984.
- [6] W. J. M. Kickert: Fuzzy Theories on Decision-Making, pp. 106—107, Martinus Nijhoff Social Science Division, Netherland, 1978.

NEW COMPLETE DECODING OF TRIPLE-ERROR-CORRECTING BINARY BCH CODES

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 17-25

[English abstract of article by Feng Guiliang [7458 6311 5328] of Shanghai Institute of Computer Technology]

[Text] A new method is given for finding out roots of one type of nonlinear equations, which appears in Van der Horst and Berger's Complete decoding of triple-error-correcting binary BCH codes. When m is even, the new complete decoding of triple-error-correcting binary BCH codes with $n=2^m-1$ requires only extracting the roots of quadratic equations and calculating at most m times inner products of m -dimensional vectors over $GF(2)$. The new complete decoding is very simple, and can be realized in practice even for moderate m . (Paper received Aug 84, finalized Nov 84.)

REFERENCES

- [1] D. C. Gorenstein, W. W. Peterson and N. Zierler: Infor. and Control, Vol. 3, pp.201—204, 1960.
- [2] C. R. P. Hartmann: IEEE Trans., Vol. IT-17, pp. 765—766, 1971.
- [3] E. F. Assmus and H. F. Mattson: IEEE Trans., Vol IT-22, pp. 348—349, 1976.
- [4] J. A. Van der Horst and T. Berger: IEEE Trans., Vol IT-22, pp. 138—147, 1976.
- [5] T. Helleseth: IEEE Trans., Vol. IT-24, pp.257—257, 1978.
- [6] F. J. Macwilliams and N. J. A. Sloane: The Theory of Error-Correcting Codes, North-Holland, New York, pp. 110—110, 1977.
- [7] 冯贵良: 电子科学学报, Vol 5, No. 6, pp. 343-348, 1983.

CMOS/SOI DEVICES FABRICATED ON Ar^+ LASER RECRYSTALLIZED POLYSILICON FILMS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 30-34

[English abstract of article by Shen Zongyong [3088 1350 7167], et al., of Shanghai Institute of Metallurgy, Academic Sinica]

[Text] CMOS/SOI devices are fabricated on Ar^+ laser recrystallized polysilicon islands on SiO_2 isolating layers. Both N-channel and P-channel MOSFET exhibit good output characteristics. The low field electron and hole mobilities of MOSFET with a channel length of $4\mu\text{m}$ are $510\text{cm}^2/\text{V.s}$ and $142\text{cm}^2/\text{V.s}$ respectively. 6-stage CMOS inverters have fine static and transient characteristics. 9-stage CMOS ring oscillators with P-channel transistors of $(W/L)=112\mu\text{m}/6\mu\text{m}$ and N-channel transistors of $(W/L)=52\mu\text{m}/6\mu\text{m}$ are fabricated. The minimum propagation delay is $2.8\text{ns}/\text{stage}$, and the minimum power delay product is $2.6\text{pJ}/\text{stage}$. These speed performance of CMOS/SOI devices are superior to those of the same CMOS devices fabricated on bulk silicon. (Paper received Dec 84, finalized Jun 85.)

REFERENCES

- [1] H. W. Lam, A. F. Tasch, T. C. Holloway: IEEE Electron Dev. Lett., Vol. EDL-1, No. 10, p. 208, 1980.
- [2] H. W. Lam, R. F. Pinizzotto, A. F. Tasch: J. Electrochem. Sec., Vol. 128, p. 1981, 1981.
- [3] T. I. Kamins, B. P. Von Hersens: IEEE Electron Dev. Lett., Vol. EDL-2, No. 12, p. 313, 1981.
- [4] B. Y. Tsaur, J. C. C. Fan, R. L. Chapman, M. W. Geis, D. J. Silversmith, R. W. Mountain: IEEE Electron Dev. Lett., Vol. EDL-3, p. 398, 1982.
- [5] 邹世昌、沈宗耀、林成鲁、倪如山、林梓鑫、姚良骥、朱桂枫: 电子学报 Vol. 11, No. 5, p. 1, 1983.
- [6] 林成鲁、沈宗耀、邹世昌: 微细加工技术, No. 1, p. 7, 1985.
- [7] H. J. Leamy et al.: Appl. Phys. Lett., Vol. 40, No. 7, p. 598, 1982.
- [8] F. Fang, C. L. Lin, Z. Y. Shen, S. C. Tsou: Nuclear Instruments and Methods in Physics Research, Vol. B7/8, p. 348-351, 1985.

A NOVEL InGaAs PHOTOTRANSISTOR BY CdO EMITTER

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 35-39

[English abstract of article by Su Liman [5685 6849 2581] of Beijing Electron Tube Factory]

[Text] A novel InGaAs phototransistor is proposed. CdO has the properties of high conductivity ($\sigma=5 \times 10^3 \Omega^{-1} \text{cm}^{-1}$) and wide forbidden gap ($E_g(\Gamma)=2.5\text{eV}$), thus it is used as the wide emitter for the transistor. Experimental results show that the transistor has a wide spectral response ($\lambda=0.5\text{-}1.6\mu\text{m}$). A current gain $h_{fe}=10$ ($V_{CE}=3\text{V}$), $I_C=1\text{mA}$) is obtained. Other results including I-V characteristic of the emitter junction, $h_{fe}-I_C$ characteristic and dark current behavior are also presented. (Paper received Oct 84, finalized Jul 85.)

REFERENCES

- [1] L. M. Su: Phys. Inst. Ser., Vol.65, p. 417, 1983.
- [2] P. D. Wright, R. J. Nelson, T. Cella: Appl. Phys. Lett., Vol. 37, p. 192, 1980.
- [3] M. Tobe, Y. Amemiya, S. Sasaki et al.: Appl. phys. Lett., Vol. 37, p. 73, 1980.
- [4] M. Miyato, K. Miyake, Y. Yamaguchi: Appl. Phys. Lett., Vol. 37, p. 180, 1980.
- [5] F. P. Kofyberg: Phys. Rev. B, Vol. 13, No. 10, p. 4470, 1976.
- [6] 苏履曼: 半导体技术, No. 1, pp. 1~5, 1985.
- [7] H. Beneking, L. M. Su: Electron. Lett., Vol. 18, p. 25, 1982.

DESIGN OF BAND-PASS FILTERS WITH WIDE-BAND USING THREE PARALLEL-COUPLED LINES

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 62-68

[English abstract of article by Liao Chengen [1675 2110 1869] of Northwest Telecommunication Engineering Institute, Xian; and Han Xiaolu [7281 2556 6922] of The 23rd Research Institute of Ministry of Electronic Industry, Shanghai]

[Text] The design principle is analysed for band-pass filters using three parallel coupled-lines and the related design curves are given. This kind of filter has many advantages such as large bandwidth, easy to design and manufacture, and gives satisfactory performance. The design examples of S-band stripline band-pass filters are given. The test results is in good agreement with calculated results. (Paper received Jul 84, finalized Jul 85.)

REFERENCES

- [1] 廖承恩, 鞠殿武: 一种新型宽带带线带通滤波器, 第三次微波通信年会暨学术交流会, 1983年10月21日。
- [2] William J. Getsinger: Coupled rectangular bars between parallel plates, IRE Trans., vol. MTT-10, No. 1, pp. 85-72, Jan. 1962.
- [3] George L. Matthaei, Leo Young, and E. M. T. Jones: Microwave Filters, Impedance-Matching Networks and Coupling Structures, McGraw-Hill Inc., pp.190-193, 217-221, 1964.

VOLTAGE RESPONSE AND RF IMPEDANCE TO EXTERNAL RADIATION FOR SUPERCONDUCTING WEAK LINKS

Beijing DIANJI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 68-77

[English abstract of article by Wu Binruo [6762 1755 5387] of Chengdu Institute of Radio Engineering, Department of Optical and Electronic Technology]

[Text] Based on the analytical solution of RSJ model with the existence of external radiation, a method for finding voltage response and RF impedance of superconducting weak links is proposed and discussed. Taking the lowest approach, the analytical expressions of the voltage response and RF impedance are obtained with this method. The results show that the impedance varies continuously on the IVC from the 0th current step to the 1st step. The analytical impedance expressions within the range of the 1st current step are deduced for the first time. (Paper received Nov 84, finalized Apr 85.)

REFERENCES

- [1] H. Kanter, F. L. Vernon, Jr: J. Appl. Phys., Vol. 43, No.7, p.3174, 1972.
- [2] F. Auracher, T. Van Duser: J. Appl. Phys., Vol. 44, No.2, p.848, 1973.
- [3] F. Auracher, T. Van Duser: Proc. Applied Superconductivity Conference, p.803, 1972.
- [4] 姚希贤: 物理学报, Vol.27, No.5, p.502, 1978.
- [5] 姚希贤: 物理学报, Vol.28, No.3, p.416, 1979.
- [6] 西北大学低温物理研究所: 超导隧道效应及其应用, p. 57, 1982 (中国制冷学会).

EARTHQUAKE RESPONSE ANALYSIS OF LARGE ANTENNA STRUCTURE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 78-84

[English abstract of article by Chen Jianjun [7115 1696 6511] and Zeng Yugeng [2582 0151 1649] of Northwest Telecommunication Engineering Institute, Xian]

[Text] Large antennas consist of a great many different kinds of elements generally, such as truss, beam, plate, shell and so on. In this paper, a wheel-track form antenna structure is discretized into multi-degree-of-freedom (2694) system and its response to deterministic earthquake is calculated by means of the finite element method. By this method, the first five natural frequencies, structure modes, displacement response history of all nodes and various maximum stress responses of all elements are obtained. Finally, some views and propositions concerning large antenna structure are put forward. (Paper received Nov 84, finalized Jun 85.)

REFERENCES

- [1] R. L. Wiegell(ed): Earthquake Engineering, 1970. (中国科学院工程力学研究所译,《地震工程学》,科学出版社,1970)
- [2] 《地震工程概论》编写组编著,《地震工程学》,科学出版社,1977.
- [3] 王光远著,《建筑结构的振动》,科学出版社,1978.
- [4] 李国豪主编,《工程结构抗震动力学》,上海科学技术出版社,1980.
- [5] 何国如、邵世勋编著,《地震强震记录的谱分析》,地震出版社,1979.
- [6] C. S. Desai, J. P. Abel: Introduction to the Finite Element Method, 1972. (江伯南、尹泽勇译,《有限元法引论》,科学出版社,1978)
- [7] 华东水利学院编,《弹性力学问题的有限单元法》(修订版),水利电力出版社,1977.
- [8] 曾余庆编,《天线结构谱分析》,西北电讯工程学院资料室,1978.
- [9] 陈建琴、曾余庆,《桁架结构随机地震响应分析》,西北电讯工程学院学报,4, pp53-61, 1984.
- [10] Meirovitch, Leonard: Elements of Vibration Analysis, McGraw-Hill, Inc., New York, 1975.
- [11] James W. Mar, Harold Liebowitz: Structure and technology for large radio and radar telescope systems, The Massachusetts Institute of Technology, 1969.
- [12] Elich, Tomonori: Earthquake effects on steel tower for microwave antennas atop building, Review of the Electrical Communication Laboratory, Vol. 23, pp. 301-315, 1975.

A NEW METHOD FOR CIRCUITS DESIGN CENTERING---CENTER RANDOM MOVE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 115-118

[English abstract of article by Yu Xiaoyong [0060 7522 0516], et al., of Guizhou Polytechnical Institute, Guiyan]

[Text] A new method for circuits design centering is described. By assuming normal distribution and identical variances, its convergence is discussed using stochastic approximation theory. Since it requires only Monte Carlo analysis and not sensitivity calculation, it is equally applicable to linear and non-linear circuits and simple to implement. Examples show that this algorithm performs well and is insensitive to nonconvexity and nonconnectivity of the region of acceptability. (Paper received Sep 84, finalized Nov 84.)

REFERENCES

- [1] R. K. Brayton et al.: Proc. IEEE, Vol. 69, pp. 1334-1364, 1981.
- [2] K. S. Tahim et al.: IEEE Trans., Vol. CAS-26, pp. 768-774, 1979.
- [3] R. S. Sois et al.: IEE Proc., G., Vol. 127, pp. 260-269, 1980.
- [4] E. Wehrhahn & R. Spence: IEEE Proc. ISCAS'84, pp. 1424-1438.
- [5] A. Ruszczyński et al.: IEEE Trans., Vol. AC-28(1983), pp. 1097-1106, 1983.
- [6] M. A. Styblinski et al.: Electr. Lett., Vol. 19, pp. 300-302, 1983.
- [7] 于晓勇, MCA-Newton法进行电路合格率估计及最优中心设计, 电子科学学报发表, 1984.
- [8] D. Agnew: IEE Proc. G., Vol. 127, pp. 270-277, 1980.
- [9] M. A. Styblinski et al.: IEEE Proc. ISCAS'81, pp. 854-857.

TWO OXYGEN DONORS IN ANNEALING NTD CZ Si

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 2, Mar 86 pp 119-124

[English abstract of article by Meng Xiangti [1322 4382 2251] of Qinghua University]

[Text] The formation and annealing behavior of the thermal donor (TD) and new donor (ND) in NTD CZ Si are studied by Hall effect, electrical resistivity and IR absorption measurements. The apparent TD concentration is decreased obviously and the ND formation can be promoted by neutron irradiation. The main cause of ND formation in NTD CZ Si is that the oxygen atoms aggregate in the disordered region due to radiation enhancing diffusion to form large size complicated silicon oxygen complex. (Paper received Sep 83, finalized Sep 85.)

REFERENCES

- [1] 孟祥提, 杜光庭, 刘开敏, 核科学与工程, Vol. 2, No. 2, p. 172, 1982.
- [2] H. M. Liaw et al.: Semiconductor Silicon, J. Electrochem. Soc., PV-77-2, p. 116, 1977.
- [3] J. W. Cleland et al.: Neutron-Transmutation-Doped Silicon, Plenum Press, New York and London, p. 55, 1981.
- [4] 孟祥提等, 清华大学核能技术研究所年报, P.30, 1980; 半导体技术, No. 2, p. 14, 1982.
- [5] 孟祥提等, 第三届全国集成电路和建材科学年会论文集, p. 100, 1983.
- [6] G. S. Fuller et al.: Phys. Rev., Vol. 90, p. 833, 1954.
- [7] P. Capper et al.: J. Appl. Phys., Vol. 48, No. 4, p. 1648, 1977.
- [8] W. Kaiser: Phys. Rev., Vol. 105, p. 1751, 1957; W. Kaiser et al.: Phys. Rev., Vol. 112, No. 5, p. 1540, 1958.
- [9] K. Graff et al.: 同(2), p. 575, 1977.
- [10] R. C. Newman et al.: J. Phys. C: Solid State Phys., Vol. 16, p. L667, 1983.
- [11] D. Helmreich et al.: ibid(2), p. 626, 1977.
- [12] 许振嘉等, 物理学报, Vol. 31, No. 10, p. 1302, 1982.
- [13] L. G. Kimerling et al.: Appl. Phys. Lett., Vol. 39, No. 5, p. 410, 1981.
- [14] Michio Tajima et al.: Japan J. Appl. Phys., Vol. 19, No. 12, p. L755, 1980.
- [15] Akihiro Kanamori et al.: J. Appl. Phys., Vol. 50, No. 12, p. 8095, 1979.
- [16] Kiyoshi Yasutake et al.: Japan J. Appl. Phys., Vol. 19, No. 9, p. L544, 1980.
- [17] 许振嘉等, 电子学报, Vol. 11, No. 2, p. 16, 1983; 电子学报, Vol. 9, No. 6, p. 58, 1981.
- [18] V. Cascarra et al.: J. Appl. Phys., Vol. 61, No. 8, p. 4206, 1980.
- [19] J. W. Corbett et al.: Phys. Rev., Vol. 135, p. A1361, 1964.
- [20] K. Hölzlein et al.: Appl. Phys. A: Solids and Surface, Vol. A34, No. 3, p. 155, 1984.
- [21] 许振嘉等, 半导体学报, Vol. 3, No. 6, p. 450, 1982.
- [22] Fumio Shimura et al.: Appl. Phys. Lett., Vol. 37, No. 5, p. 483, 1980.
- [23] V. D. Akhmetov et al.: Phys. Stat. Sol.(a), Vol. 75, No. 2, p. 601, 1983.
- [24] I. D. Konozenko et al.: Radiation Damage and Defects in Semiconductors, Inst. of Physics, London and Bristol, p. 289, 1973.

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CSO: 4009/1067

Engineering

THE RESPONSE ANALYSIS OF VIBRATION SYSTEMS TO NONZERO MEAN RANDOM EXCITATION

Beijing QINGHUA DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF TSINGHUA UNIVERSITY (NATURAL SCIENCE)] in Chinese Vol 26, No 2, Apr 86 pp 1-12

[English abstract of article by Wang Hexiang [3769 0735 4382] et al., of Department of Engineering Mechanics]

[Text] An equivalent linearization method for obtaining the response of non-linear multi-degree-of-freedom dynamic systems to nonstationary Gaussian excitation with nonzero mean is presented. Using the property of Gaussian vector processes, the closed formulas of the coefficients of the equivalent linear system are obtained. The linear coefficients obtained are as simple as those of the Atalik and Utku method in mathematical form. A method to treat stochastic dynamic equation of complicated structure by means of modal truncation method and to compute response statistics of dynamic system in the time domain is presented. One numerical method to compute mean and covariance equations of stochastic dynamic system is presented. (Paper received Apr 85.)

REFERENCES

- [1] T. K. Caughey, *Adv. appl. Mech.*, 11(1971)
- [2] W. D. Iwan and I. N. Yang, *J. appl. Mech.*, 39 (1972)
- [3] S. T. Atalik and S. Utku, *Earthq. Engng. Struct. Dynamics*, 4(1976)
- [4] W. D. Iwan and A. B. Mason, *Int. J. Nonlinear Mech.*, 15, 2(1980)
- [5] R. E. Nickell, *Computer Methods in Applied Mechanics and Engineering*, 7 (1976)
- [6] L. D. Ofmeister, *Computer and Structure*, 8(1978)
- [7] 郑兆昌, 《应用数学和力学》, 4, 4(1983)
- [8] 蔡坚, 清华大学工程力学系硕士论文, 1984.9.
- [9] B.C. 普加切夫: 《随机函数理论及其在自动控制中的应用》(中译本), 科学出版社, 1966.
- [10] 王照林等编: 《现代控制理论基础》, 国防工业出版社, 1981
- [11] 郑兆昌、程保荣, 《海洋工程》, 2(1984)
- [12] 王和祥、张宪宏、蔡坚, 《地震工程与工程振动》, 4 (1985)

ANALYSIS OF THE FLASHOVER CRITERION OF POLLUTED INSULATOR UNDER DC VOLTAGE

Beijing QINGHUA DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF TSINGHUA UNIVERSITY (NATURAL SCIENCE)] in Chinese Vol 26, No 2, Apr 86 pp 59-68

[English abstract of article by Guan Zhicheng [7070 1807 2052], et al., of Department of Electrical Engineering]

[Text] The volt-ampere characteristics of the arc developing along the surface of polluted insulator and the surface conductivity of remainder pollution layer were measured. The effective surface conductivity γ_e was proposed and the method to determine it was presented. A new method to calculate the DC flashover criterion of polluted insulator was proposed. Experimental data of some insulators are in agreement with the calculated results. (Paper received Feb 85.)

REFERENCES

- [1] F. Obenaus, *Disch. Electrotechnik*, 12, 4(1958), 135—136
- [2] L. L. Alston, et al., *PIEE*, 110, 7(1963), 1260—1266
- [3] A. M. Rahal, et al., *IEEE, PAS—98*, 6(1979), 2223—2231
- [4] R. Wilkins., *PIEE*, 113, 3(1969), 457—465
- [5] B. F. Hampton., *PIEE*, 111, 5(1964), 985—990
- [6] 关志成: 《染污绝缘子临闪前泄漏电流和污闪电压之间关系的研究》, 清华大学硕士研究生论文, 1981
- [7] 关志成: 《在交、直流电压下染污绝缘子闪络条件的分析计算和试验研究》, 清华大学博士研究生论文, 1984

FAULT LOCATION OF FLUID TRANSPORT PIPELINE BASED ON MODELLING AND ESTIMATION METHODS

Beijing QINGHUA DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF TSINGHUA UNIVERSITY (NATURAL SCIENCE)] in Chinese Vol 26, No 2, Apr 86 pp 69-75

[English abstract of article by Tao Luowen [7118 3157 2429], et al., of Department of Automation]

[Text] The normal operation of long-distance oil, gas, water or slurry transport pipeline may be troubled by faults such as blockage and leakage. A new method based on modelling and estimation is proposed to locate the faults by a microcomputer and two pressure transducers, both set at one end of the pipe. By analyzing the impulse response of the estimated model, the location of the blockage or leakage (not less than 10 percent) can be determined to an accuracy of 0.5 percent. This method has been verified in an experimental liquid transport pipeline. (Paper received Jan 85.)

REFERENCES

- [1] Butler, N. C., *Process Engineering*, 10, 7(1982), 81—85
- [2] Isermann, R., *Automatica*, 20(1984), 387
- [3] Siebert, H., *Process Automation*, 2(1981), 90
- [4] 陶洛文: 《以辨识为基础的长输管线故障定位》, 硕士学位论文, 清华大学自动化系, 1984
- [5] Wylie, E. B. and V. L. Streeter: *Fluid Transients*, McGraw-Hill Book Co., New York, 1978
- [6] Sharp, B. B.: *Water Hammer*, Edward Arnold Ltd., London, 1981

FATIGUE ANALYSIS OF SPECIMENS WITH COMPLICATED STRESS FIELD

Beijing QINGHUA DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF TSINGHUA UNIVERSITY (NATURAL SCIENCE)] in Chinese Vol 26, No 2, Apr 86 pp 84-95

[English abstract of article by Yan Yongnian [7346 3057 1628], et al., of Department of Mechanical Engineering and Zhou Chuntian [0719 2504 3944], et al., of Department of Engineering Mechanics]

[Text] The fatigue test of specimens with complicated stress field and its analysis show that the intensity of stress field method can be used for correct judgement for the dangerous part of component with complicated stress field and for the estimation of its fatigue life with appropriate accuracy. (Paper received Nov 84.)

REFERENCES

- [1] 郑楚鸿:《高周疲劳设计方法——应力场强法》,清华大学工学博士学位论文, 1984,3
- [2] H. O. Fuchs, R. I. Stephens: *Metal Fatigue in Engineering*, John Wiley & Sons, 1980
- [3] 周春田, 勾秋静:《循环载荷下缺口板弹塑性应变分布测定》,清华大学材力实验室, 1983
- [4] R. A. Smith and K. J. Miller, *Int. J. Mech. Sci.*, 19, (1977), 11—22
- [5] N. E. Dowling, *Fracture Mechanics*, ASTM STP677, (1979), 247—273
- [6] 顾鸣泉: *Some Microscopic Features and Mechanisms of Fatigue Behaviour in Metals*, 1st China—U. S. A. Bilateral Metallurgical Conference, 1981, 11
- [7] D. 布洛克:《工程断裂力学基础》,王克仁等译,科学出版社, 1980,5
- [8] Huseyin Sehitoglu, *Eng. Fracture Mech.*, 18, 3(1983), 609—621
- [9] 徐灏:《疲劳强度设计》,机械工业出版社, 1981

DECORATIVE COATING OF TiN IN GOLDEN COLOR ON CERAMIC SUBSTRATES BY CHEMICAL VAPOR DEPOSITION

Beijing QINGHUA DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF TSINGHUA UNIVERSITY (NATURAL SCIENCE)] in Chinese Vol 26, No 2, Apr 86 pp 96-104

[English abstract of article by Cai Zuoqian [5591 0155 0051], et al., of Department of Chemistry]

[Text] Experiments were carried out to produce TiN coating in golden color on ceramic substrate by CVD technique using $TiCl_4$, NH_3 , N_2 and H_2 . The region of proper deposition temperature is at $800^\circ C$ to $850^\circ C$. Satisfactory lustrous coating of TiN in golden color was obtained when the amount of the flow of gas reactants got smaller. The composition of the coating deposited on ceramics is close to stoichiometric TiN, i.e. the value of atomic ratio N/Ti is approximate to 1:1. The lattice parameter a_0 equals to $4.241\text{\AA}$. The lightness reached the level of gold. Because of its high hardness, the TiN coating gives a higher wear resistant than the gold coating with a high chemical stability. (Paper received Mar 85.)

REFERENCES

- [1] Г.В.Самсонов, Т.С.Верхоглядова, Журнал Структурной Химии, 2 (1961), 617
- [2] Robert C. Weast; CRC Handbook of Chemistry and Physics, 63rd (1982—1983)
- [3] 池永勝, 工業材料, 32, 3(1984), 51
- [4] John R. Peterson, J. Vac. Sci. Technol, 11(1974), 715
- [5] W. Schintlmeister, O. Pacher and K. Pfaffinger, J. Electrochem. Soc., 123 (1976), 924
- [6] W. Schintlmeister and O. Pacher, J. Vac. Sci. Technol., 12(1975), 743
- [7] P. J. M. Van der Straten and G. Verspui, Phillips Tech. Rev., 40, 7(1982), 204—210
- [8] H. O. Pierson, Thin Solid Films, 40(1977), 41
- [9] 日本专利, 公開特許公報, 昭 57-108260(82, 108260)
- [10] W. Junghans und R. Wilberg, H. Liebmann und H. Schmidt, Silikattechnik, 33, (1982), 365
- [11] 张克敏, 蔡作乾, 《物理》, 13, 12 (1984), 732-736
- [12] A. Kato and N. Tamari, J. Cryst. Growth, 29(1975), 55—60

THE INVERSE SYSTEM METHOD AND ITS APPLICATION

Beijing QINGHUA DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF TSINGHUA UNIVERSITY (NATURAL SCIENCE)] in Chinese Vol 26, No 2, Apr 86 pp 105-114

[English abstract of article by Li Chunwen [2621 2504 2429] and Feng Yuankun [7458 0337 3824] of Department of Automation]

[Text] A new method, called inverse system method, is proposed for the synthesis of a class of multivariable analytic nonlinear control systems. It consists of two parts: constructing at first an " α integral inverse system" which can be realized by state feedback from the inverse of the original system, so that a "pseudo-linear system" is formed through precompensation of the α integral inverse system and a linear relation exists between its input and its output; then, designing the controller of the pseudo-linear system by the well known linear system theories, e.g., decoupling, pole assignment, linear quadratic optimal and robust regulator, etc. The inverse system method was used in the design of the dynamic control system of robot manipulator. Some digital simulation results given in the paper prove that the inverse system method is effective. (Paper received Mar 85.)

REFERENCES

- [1] J. Marshik, 《第一届 IFAC 会议论文集选集》, (中译本), 上海科技出版社, 1963
- [2] 韩京清, 《全国控制理论及其应用学术交流会议论文集》, 科学出版社, 1979
- [3] H. Nijmeijer, IEEE Trans. Automat. Contr., Ac-28, 8(1983), 861—862
- [4] S. N. Singh, IEEE Trans. Automat. Contr., Ac-25 (1980), 1237—1239
- [5] L. M. Silverman, IEEE Trans. Automat. Contro., Ac-14 (1969), 270—276
- [6] R. M. Hirschorn, IEEE Trans. Automat. Contr., Ac-24 (1979), 855—865

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CSO: 4009/1076

Engineering Thermophysics

A FAST AC-AF ALGORITHM FOR SOLVING THE CONSERVATIVE TRANSONIC 3D POTENTIAL EQUATION EMPLOYING NON-ORTHOGONAL CURVILINEAR COORDINATES AND NON-ORTHOGONAL VELOCITY COMPONENTS

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 7, No 1, Feb 86 pp 7-12

[English abstract of article by Zhang Jialin [1728 1367 7792] of Institute of Engineering Thermophysics, Academia Sinica]

[Text] A conservative full-potential equation of 3D transonic flow in a turbomachine has been derived with the tensor method and expressed with respect to nonorthogonal curvilinear coordinates, and a full implicit artificial compressibility--approximate factorization scheme to calculate the flow field has been developed in this paper. The new algorithm has been used to compute the 3D transonic flow field within the axial-flow single-stage compressor rotor tested by DFVLR. Comparisons between the computed flow field and the DFVLR data have been made. Results demonstrate that fast convergence can be achieved by the presented algorithm and that the agreement with the measurements obtained with an advanced laser velocimeter is quite good.

CALCULATION OF THREE-DIMENSIONAL FLOW WITH JET-WAKE MODEL IN CENTRIFUGAL PUMPS

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 7, No 1, Feb 86 pp 13-19

[English abstract of article by Liu Diankui [0491 3013 7608] of Institute of Engineering Thermophysics, Academia Sinica]

[Text] Expanding the slip factor which comes from a lot of experimental data into three dimensional flow, a calculation method of Jet-Wake model which is based on Prof. Wu's theory is presented here.

A redesign of a centrifugal pump impeller has been done to verify the method. The experimental results show that the efficiency of the pump is increased by 4 percent. Therefore, the method is useful to improve one dimensional design method which is used widely abroad and at home up to now.

COMPUTATION METHODS OF INVERSE AND SEVERAL MIXED AERODYNAMIC PROBLEMS FOR
TRANSONIC CASCADES

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in
Chinese Vol 7, No 1, Feb 86 pp 20-24

[English abstract of article by Wang Zhengming [3769 2973 2494] of Institute
of Engineering Thermophysics, Academia Sinica]

[Text] The computation methods of the inverse and several mixed aerodynamic problems for transonic cascades are presented. The calculations are completed directly on the physical plane by the stream function equation. The corresponding boundary conditions of these problems are transferred into the boundary conditions expressed by stream function with the help of the relations of the basic equations. The methods presented have a clear physical concept and use similar manners of iteration for different problems. The calculations of some examples for the transonic inverse problem indicate this method is very effective. An example is given of a shockless supercritical cascade designed successfully by the transonic inverse code.

A NEW METHOD FOR SOLVING AERODYNAMIC HYBRID PROBLEM OF PROFILE CASCADE ON S_1 STREAM SURFACE OF REVOLUTION BY EMPLOYING STREAM FUNCTION EQUATION EXPRESSED WITH NON-ORTHOGONAL COORDINATE SYSTEM

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 7, No 1, Feb 86 pp 25-29

[English abstract of article by Chen Naixing [7115 0035 5281] and Li Weihong [2621 5898 4767] of Institute of Engineering Thermophysics, Academia Sinica]

[Text] A new method is developed in the present paper for solving an aerodynamic hybrid problem of profile cascade on S_1 stream-surface of revolution by employing stream function equation on non-orthogonal coordinate system. For this kind of problems the shape of a portion of the blade profile is unknown. The remainder is determined by a giving prescribed velocity distribution. Four examples of blade cascades have been carried out to examine this method. It is shown that the calculation method presented herein can be used as a powerful tool together with aerodynamic optimization method for blade cascade design.

A MATHEMATICAL MODEL FOR CALCULATION OF EFFECTS OF AIR HUMIDITY FUEL COMPOSITION
AND GAS DISSOCIATION ON ENGINE PERFORMANCE AND ITS ACTUAL APPLICATION

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in
Chinese Vol 7, No 1, Feb 86 pp 55-57

[English abstract of article by Gu Yonggen [7357 3057 2704] of Nanhua Powerplant
Research Institute Zhuzhou, Hunan, China]

[Text] This paper presents a mathematical model for computation of the effects
of air humidity, fuel composition and gas dissociation on gas turbine engine
performance. The programmed model was also successfully applied to a computer
program for simulation of gas turbine engine performance, called a 'TURBOFLEXI'.
The results from it is in good agreement with the published data.

VARIATIONAL PRINCIPLES (VP_s) & GENERALIZED VP_s FOR 3-D TRANSONIC FLOW WITH SHOCK WAVES IN A ROTATING TURBO-IMPELLER (II)

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 7, No 1, Feb 86 pp 58-61

[English abstract of article by Liu Gaolian [0491 7559 5114] of Shanghai Institute of Mechanical Engineering]

{Text} As a further development of Ref. [1] two VP families for 3-D transonic potential-, Beltrami- and rotational flows with shocks in rotors in terms of stream functions are established. Functional variations with variable domain are used with success to handle unknown discontinuities (shocks, free trailing vortex sheets etc.), converting the matching conditions across them (including the Rankine-Hugoniot shock relations) into natural ones. A sound theoretical basis is thus provided for the FE analysis of transonic flow.

APPLICATIONS OF DOUBLE FILM HEAT FLUX GAUGES IN HEAT TRANSFER TEST OF TURBINE

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 7, No 1, Feb 86 pp 62-65

[English abstract of article by Cao Yuzhang [2580 3768 3864] of Beijing Institute of Aeronautics and Astronautics, China]

[Text] This paper presents applications of double film heat flux gauges in the experimental study of turbine heat transfer and discussions of the data obtained from MIT turbine blowdown facility. The result shows that the small fluctuation of temperature on the measured surface at high frequency will cause the large fluctuation of heat transfer rate.

EXPERIMENTAL STUDY ON COMBUSTION OF FLAME OF COAL-WATER MIXTURE

Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 7, No 1, Feb 86 pp 87-90

[English abstract of article by Lu Deshou, et al., of Zhejiang University]

[Text] The results of the preliminary CWM combustion experiments carried out in a tunnel testing furnace with its thermal rate of 4.187×10^6 watt are presented. The CWM with the coal concentration of 64 ~ 68 percent (in Weight) and viscosity of 700 ~ 1100 cp can be smoothly transported and well atomized, and can be dependably ignited and stably burned when the combustion air temperature is between ambient and 330°C, with the conversion efficiency up to 98 percent. The experimental result; of blue gas temperature blue gas composition and combustible matter burn-nut within the furnace are also given in the paper.

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ON THE NTH ORDER WAVE INTERACTION THEORY

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 3,
20 Mar 86 pp 129-140

[English abstract of article by Tan Weihai [6223 4850 5060] of Shanghai Institute
of Optics and Fine Mechanics, Academia Sinica]

[Text] The nth order wave interaction theory investigated in this paper should
be considered as a continuation of the "exact solution to solitary wave equa-
tions of light interaction with two-level atomic systems" in the earlier paper^[1].

In literature^[4,5] the third order wave equations originate from the research
of three-wave interaction. But the nth order wave equations considered now
are derived from the n-dimensional vector functions which satisfy two nonlinear
equations, and the general solutions can be expressed in terms of the upper
hemiplane analytical solutions and the lower hemiplane analytical solutions.
These results include the 2nd and the 3rd order solutions as a special example.

FREE-ELECTRON LASERS WITH TAPERED WIGGLERS: A DISCUSSION ON THE CASE WITH AXIAL MAGNETIC FIELD

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 3, 20 Mar 86 pp 147-151

[English abstract of article by Wang Yuandian [3769 0337 3013] of Institute of Space Physics, Academia Sinica]

[Text] It is pointed out in this paper that in order to increase efficiency of free-electron lasers with axial magnetic field, tapered wigglers can be applied. At the same time, general formulae for calculation of the parameters of the tapered wigglers have been derived, too. A comparison has been made between the two cases with and without axial magnetic field.

A NEWLY DESIGNED PULSED AND OPTICALLY-PUMPED FIR LASER

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 3,
20 Mar 86 pp 152-156

[English abstract of article by Pan Chengzhi [3382 2110 1807], et al., of
Beijing Research Institute of Vacuum Electron Devices]

[Text] A pulsed and optically-pumped FIR laser with a mesh coupling and a
stable cavity has been designed. Its cavity length can be adjusted. 5 FIR
laser lines at 205.3 μ m, 163.9 μ m, 65.1 μ m and 233 μ m emitted from CH_3OH and
309.23 μ m from HCOOH have been obtained.

FREQUENCY STABILIZED DYE LASER OSCILLATOR-AMPLIFIER SYSTEM FOR HIGH RESOLUTION SPECTROSCOPY

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 3, 20 Mar 86 pp 157-160

[English abstract of article by Xia Jingfang [1115 2417 5364] of Laser Physics Lab., Dept. of Physics, Fudan University]

[Text] This paper describes a frequency stabilized dye laser oscillator-amplifier system for high resolution spectroscopy. It uses frequency doubled output of a Q-switched Nd:YAG laser to pump a system that amplifies the output of a frequency stabilized CW dye laser to provide near Fourier transform limited pulses of 1 MW peak intensity. A new method for laser frequency stabilization is also presented.

NARROW BANDWIDTH TUNNING OF RHODAMINE 6G DYE PUMPED BY XeCl EXCIMER LASER

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 3, 20 Mar 86 pp 161-163

[English abstract of article by Shangguan Cheng [0006 1351 6134], et al., of
Shanghai Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] In this paper the experimental study for narrow bandwidth tuning of
ethyenglycol solution of rhodamine 6G pumped by a XeCl excimer laser is report-
ed. The tunable range from 572.7nm to 612.9 nm with linewidth of 0.004 nm
has been obtained. The conversion efficiency is 16.0 percent. The experimen-
tal results of other seven dyes are also presented.

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CSO: 4009/89

CHARACTERISTICS OF PICOSECOND PULSES GENERATED FROM SYNCHRONOUSLY PUMPED DYE LASER SYSTEM--THE THIRD ORDER EXPANSION OF GAIN OF MODE-LOCKED EQUATION AND ITS SOLUTION

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 4, 20 Apr 86 pp 193-196

[English abstract of article by Bao Xiaoyi [7637 2556 3015] and Guan Xinan [7070 0207 1344] of Department of Physics, Nankai University]

[Text] In this paper, we present the third order expansion of gain of mode-locked equation, and solved the equation with Lagrange multiplier method. The results provide simple analytical expressions for the pulsewidth, pulse intensity and delay (which is the advance of the pump pulse relative to the dye pulse) in synchronously pumped dye laser. They can explain satisfactorily some experimental results[4].

STIMULATED RAMAN SCATTERING OF UNPOLARIZED LONG PULSE XeCl EXCIMER LASER
RADIATION IN H₂

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 4, 20 Apr 86 pp 197-199

[English abstract of article by Lou Qihong [2869 4388 3163] et al., of Shanghai
Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] Stimulated Raman scattering (SRS) experiments in hydrogen were performed
with a collimated beam from an X-ray preionization discharge XeCl laser operating
at 308 nm. The photodiode output profile S₁, S₂ and S₃ stokes lines were obser-
ved. The reduction of beam spread angle and pulse duration of SRS were analysed
theoretically.

TWO-PASS AMPLIFICATION ATOMIC IODINE LASER AMPLIFIER

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 4, 20 Apr 86 pp 207-211

[English abstract of article by Chen Shisheng [7115 2514 0524] of Shanghai
Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] In this paper, we report the experimental results of a two-pass amplification atomic iodine laser amplifier. For an iodine amplifier working under the condition lower than those in the saturation region, two-pass amplification can increase the efficiency of the iodine laser amplifier obviously. Besides, we found that He is the best among He, Ar, SF₆ usually used as buffer gases in iodine lasers. It has obvious advantages especially in reducing the beam deformation produced by optical pumping and in holding beam direction.

MANIFESTATION OF ROTATIONAL NONEQUILIBRIUM IN A CW DF CHEMICAL LASER

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 4, 20 Apr 86 pp 216-217

[English abstract of article by Sang Fengting [2718 7685 0080] et al., of Dalian
Institute of Chemical Physics, Academia Sinica]

[Text] The rotational nonequilibrium phenomenon in a CW DF chemical laser
was experimentally studied. The dual-peak character in the output spectral
intensity profile was observed with a fast mixing nozzle for the first time.
The same phenomenon does not occur with slow mixing nozzles, nor with HF as
lasant.

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CSO: 4009/90

PROBLEMS ON GENERATION OF CONTINUOUSLY TUNABLE VUV COHERENT RADIATION BY FOUR WAVE-MIXING

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 5, 20 May 86 pp 257-262

[English abstract of article by Li Binxue [2621 1755 1331] and Huang Yongkai [7806 3057 2818] of Shanghai Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] The theory and experimental results on acquiring VUV coherent sources by four wave-mixing process are briefly described. An analysis of the important aspects for effective generation of VUV coherent radiation by FWM is presented.

A LOW JITTER TWO CHANNEL DISCHARGE PUMPED EXCIMER LASER

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13,
No 5, 20 May 86 pp 270-272

[English abstract of article by Hu Xuejin [5170 7185 6855] et al., of Anhui
Institute of Optics and Fine Mechanics, Academia Sinica]

[Text] A two channel fast discharge pumped excimer laser was designed. The jitter time between two output laser beams was measured as ± 1 ns at the operation pressure of 1 atm, and ± 5 ns at 2 atm, respectively. The output energy of each channel was 80-100 mJ, the maximum was approximately 150 mJ.

EXPLANATION AND DISCUSSION ON THE REPORTED EXPERIMENTAL RESULTS OF CHARACTERISTICS
OF PICOSECOND PULSE GENERATED FROM SYNCHRONOUSLY PUMPED DYE LASER SYSTEM

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 5,
20 May 86 pp 273-276

[English abstract of article by Bao Xiaoyi [7637 2556 3015] and Guan Xinan
[7070 0207 1344] of Department of Physics, Nankai University]

[Text] In this paper, we give the simple analytic expressions of picosecond
pulses in synchronfously pumped dye laser, and also some discussion and explana-
tion based on the above theoretical results. This theory proved especially
that for the pulsewidth and average power of synchronously pumped dye laser
there exists an optimum value.

EXCURSION OF ALIGNED LASER BEAM THROUGH ATMOSPHERE ABOVE WATER SURFACE AND LAND

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 13, No 5, 20 May 86 pp 302-305

[English abstract of article by Ma Jian [7456 1696] and Tang Wu [0781 2976] of Shanghai Institute of Laser Technology, and Shen Shanxiong [3088 3790 7160] et al., of Department of Physics, East Teachers University]

[Text] Laser beam excursion through atmosphere above the water surface and the land is presented. The results show that the beam excursion curves of the two paths have similar outline and cycle, and are similar to those of the temperature except of their phase ahead of 0.17-0.21 π . The amount of beam excursion through the land path h_L in vertical direction in one cycle 24 hrs is greater than that of the water path h_w , and h_L/h_w equals to 1.14 - 1.40.

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CSO: 4009/91

A SIMPLE NEUTRON-GAMMA DISCRIMINATING SYSTEM

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 3, Mar 86 pp 11-14

[English abstract of article by Liu Zhongming [0491 0022 2494] et al., of Shanghai Institute of Nuclear Research, Academia Sinica]

[Text] A simple neutron-gamma discriminating system is described. A detector and a pulse shape discriminator are suitable for the neutron-gamma discriminating system. The influence of the constant fraction discriminator threshold energy on the neutron-gamma resolution properties is shown. The neutron-gamma timing distributions from an ^{241}Am -Be source, 2.5MeV neutron beam and 14MeV neutron beam are presented.

Keywords: neutron-gamma discriminating system resolution property timing distribution

A STUDY ON THE SURFACE DAMAGE OF R-IBE CRYSTALS BY RBS-CHANNELING TECHNIQUE

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 3, Mar 86 pp 19-21

[English abstract of article by Cao Dexin [2580 1795 2450], et al., of Shanghai Institute of Nuclear Research, Academia Sinica]

[Text] This paper reported the study on the surface damage, and its annealing of R-IBE (reaction ion beam etched) crystal by RBS-channeling technique. The topography of the etched surface was observed by SEM.

The experimental results show that the reactive ion beam etching with CF_4 results in a surface damage layer and the amount of the damage increases with increasing the energy of the ion beam.

**Keywords: reaction ion beam etching damage thermal annealing
channeling technique**

THE INFLUENCES OF THE THICKNESS OF CARBON STRIPPING FOIL ON THE CHARGE STATE DISTRIBUTION

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 3, Mar 86 pp 30-31

[English abstract of article by Sun Yunmin [1327 7301 2404] and Shao Mingzhu [6730 2494 3796] of Institute of Modern Physics, Academia Sinica]

[Text] This paper describes an experiment about the effect of the thickness of stripping carbon foils on the charge state distribution of carbon and neon which are extracted from 1.5m classical cyclotron. The energies of the particles are 72 MeV and 140 MeV respectively. The results show that the thicker foils were used, the more number of the high charge state particles were obtained after stripping.

Keywords: thickness of carbon stripping foil charge state distribution

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CSO: 4009/96

A LIQUID SCINTILLATION NUCLEAR ACTIVITY METROLOGY INSTRUMENT

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 6, Jun 86 pp 4-9

[English abstract of article by Wang Zhangzhi [3769 4545 2535], et al., of Shanghai Institute of Nuclear Research, Academia Sinica]

[Text] A new precise instrument for determination of the absolute disintegration of β , α emitter solutions by the method of liquid scintillation counting is described. The instrument includes a triple phototube liquid scintillation detector and three output counting channels which are used for the number of triple coincidences N_c , the number of sum of double coincidences N_d and the number of sum of single phototube counting N_g separately. This instrument is based on the principle of extrapolating the triple to double coincidence ratio (TDCR) to unity.

Examples of application of the instrument for ^3H and ^{14}C are given.

The instrument has two main advantages: 1. Higher accuracy. The overall measurement uncertainty (3σ), for ^3H , ^{63}Ni , ^{35}S and ^{14}C etc. is in 0.5-1.5 percent. 2. Easy to operate. The measurement time is much less than usual metrology instrument.

Keywords: liquid scintillation counting activity metrology TDCR

ELECTRIC QUADRUPOLE INTERACTIONS IN $\text{In}_{0.95}\text{Ag}_{0.045}\text{Ga}_{0.005}$ ALLOY

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 6, Jun 86 pp 10-13

[English abstract of article by Zhu Shengyun [2612 0581 0061], et al., of Institute of Atomic Energy, Academia Sinica]

[Text] The temperature dependence of the quadrupole interaction of ^{111}Cd in $\text{In}_{0.95}\text{Ag}_{0.045}\text{Ga}_{0.005}$ alloy is determined by the time differential perturbed angular correlation (TDPAC) method from 80 to 422K. The electric field gradients produced by the lattice in the alloy are derived. The temperature dependence of the electric field gradient follows the $T^{3/2}$ law: $V_{zz}(T) = V_{zz}(0) (1 - B^{5/2})$ with a slope $B = 7.48(47) \cdot 10^{-5} \text{K}^{-3/2}$. The FWHM's of the electric field gradient are 0.1147(259), 0.0924(340) and 1.344 (175) at 80, 298 and 422 K, respectively. This indicates that the characteristics of the lattice structure of the alloy are better at 80 and 298 K than at 422K.

Keywords: TDPAC method quadrupole interaction electric field gradient
 $T^{3/2}$ law

A CEMS STUDY OF THE ION IMPLANTED LAYER OF SMALL BUBBLE DIAMETER GARNET MATERIAL

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 6, Jun 86 pp 30-34

[English abstract of article by Wang Lixuan [3769 4539 5503], et al., of Shanghai Institute of Nuclear Research, Academia Sinica]

[Text] This paper describes an ^{57}Fe conversion electron Mossbauer spectroscopic study of small bubble diameter material. The nominal composition of the film is $(\text{YLuBi})_3 - (\text{FeGa})_5 \text{O}_{12}$. After a dosage of 5×10^{13} to $1 \times 10^{14} \text{ cm}^{-2}$ 100 keV Ne^+ implantation, peaks of 2 and 5 of CEMS are emerged, indicating that the magnetization vector M_s of the surface layer of the film is toward the film plane. It was found that the stress induced magnetic planar anisotropy owing to the dosage of ion implantation is not necessary to be very large. While $d = 2 \times 10^{14} \text{ cm}^{-2}$, only paramagnetic spectra are obtained but the a and d site spectrum is distinguishable. When $d > 7 \times 10^{13} \text{ cm}^{-2}$, hard bubbles are suppressed. High temperature 1050°C annealing is required to restore the hyperfine field to the value in the as-grown state, however, peaks 2 and 5 are present in the spectra and hard bubbles are still suppressed.

Keywords: CEMS ion implantation garnet material small bubble diameter

**A DEVICE OF DOUBLE CONTROL OF VOLTAGE REGULATION AND BREAKDOWN PREVENTION
OF VAN DE GRAAFF ACCELERATOR**

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 6, Jun 86 pp 38-40

[English abstract of article by Fan Zhifang [5400 1807 2455] of Institute
of High Energy Physics, Academia Sinica]

[Text] The principle of a double control and breakdown prevention device is described. The operational performances are described. It has been proved experimentally that this device can effectively prevent the accidentally terminal voltage rising that may result a destructive breakdown. With the help of the device, the energy of accelerated particles has been increased from 2.0 MeV to 2.88 MeV, the regulation of beam is also made much more convenient and safer, and the voltage stability has been improved noticeably.

Keywords: Van de Graaff accelerator double control voltage regulation
protection against over voltage rotating voltmeter control linearly
the triode to control corona current

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CSO: 4009/92

INFLUENCE OF α -NUCLEUS ALAS POTENTIAL ON THE $^{40}\text{Ca}(\alpha, p)^{43}\text{Sc}$ REACTION

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7, No 3, Aug 85 pp 226-234

[English abstract of article by Bao Xiumin [7637 4423 2404], et al., of Institute of Atomic Energy, P.O. Box 275, Beijing]

[Text] To clarify the ambiguities of the explanations of the ALAS (α -nucleus anomalous large angle scattering), (α, p) reactions are used to test several α -anomalous potentials, which have well explained the ALAS. The differential cross sections of $^{40}\text{Ca}(\alpha, p)^{43}\text{Sc}$ reaction to ground state ($7/2^-$), 0.472 MeV ($3/2^-$) and 1.179 MeV ($3/2^-$) state are measured, the energy of α particles is 25.8 MeV. An additional peak around 110° region is observed. DWUCK4 program is modified for calculations using α -anomalous potentials. It is found that for the lower and higher partial waves of the incident channel wave function, the imaginary l -dependent potential can provide a reasonable description, but the WS^2 , $WS^2(s)$, $WS^{2.65}$ and WS^5 type potentials cannot give the correct behaviour for the lower partial waves, so it is unable to reproduce the angular distributions of (α, p) reactions.

Key words (α, p) reaction, ^{40}Ca , DWBA calculation.

THE MASS DISTRIBUTION IN 14.9 MeV NEUTRON-INDUCED FISSION OF ^{238}U

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7.
No 3, Aug 85 pp 235-241

[English abstract of article by Liu Conggui [0491 1783 6311], et al., of Institute of Atomic Energy, P.O. Box 275, Beijing]

[Text] The mass distribution for the 14.9 MeV neutron-induced fission of ^{238}U is measured using Ge(Li) γ ray spectrum method. The absolute measurement of fission rate is carried out by a double ionization chamber. The absolute activities of fission products are determined by a Ge(Li) detector. Thirty-nine mass chain yields and one cumulative yield are obtained in the region $A=84-151$. Among them thirteen yields are measured relatively to the yields of ^{132}Te or ^{140}Ba . The yields measured make up about 131.97 percent of the total of 200 percent expected from fission. The present results are compared with other measurements. As reported by others previously, a fine structure is observed at the mass number of 134, in other mass region no clear evidence could be found.

Key words Fission yields, Mass distribution, Ge(Li) γ ray spectrum method, Absolute measurement.

COMMENTS ON THE NEW NEUTRINO "BALANCE": A DISCUSSION OF THE FEASIBILITY OF USING THE ELECTRON CAPTURE PROCESS IN ^{158}Tb , ^{157}Tb AND ^{163}Ho FOR NEUTRINO MASS DETERMINATION

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7, No 3, Aug 85 pp 246-251

[English abstract of article by Qing Chengrui [1987 2110 3843], et al., of Institute of Theoretical Physics, Academia Sinica, P. O. Box 2735, Beijing]

[Text] It is pointed out that there are two main difficulties for neutrino mass determination in the K electron capture in $^{158}\text{Tb} \rightarrow ^{158}\text{Gd}$ (1187). One of them is that the atomic structure must be calculated with high precision, and the other is that the maximum energy of photons E_Y^{max} accompanied with the capture must be determined independently. However, it is possible to determine the neutrino mass with accuracy about 10-30 eV by using the M1, M2, N1, electron capture in ^{163}Ho (7/2-) $\rightarrow$ ^{163}Dy (5/2-) or the L1, L2, M1, M2 electron capture in $^{157}\text{Tb} \rightarrow ^{157}\text{Gd}$ (5/2-) if the newly measured Q values of them are correct. Particularly, with the aid of the L1, L2, M1, M2 electron capture in $^{157}\text{Tb} \rightarrow ^{157}\text{Gd}$ (3/2-), neutrino mass can be determined independent of the nuclear matrix and the electron wave functions.

Key words Neutrino mass, Electron capture, ^{157}Tb , ^{158}Tb , ^{163}Ho .

THREE CRYSTAL PAIR SPECTROMETER

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7, No 3, Aug 85 pp 273-278

[English abstract of article by Zeng Xiantang [2582 2009 1016], et al., of Institute of Atomic Energy, P.O. Box 275, Beijing]

[Text] Using a HPGe ($\phi 4.3 \times 2.5$ cm) as the central detector and two cylindrical NaI(Tl) ($\phi 12.5 \times 10.0$ cm) as the outside detectors, a three crystal pair spectrometer is built up. In order to increase double escaping efficiency and improve energy resolution, the central HPGe is mounted transversely, so that γ rays are incident upon the side of HPGe cylinder. The spectrometer is operated in single mode below 3 MeV and in pair mode above 2 MeV. For ^{24}Na 2.754 MeV γ ray double escaping peak, the ratio of the peak to adjacent continual background is 8.5 in single mode, 350 in pair mode, the actual improvement factor is 41. The influence of annihilation photon "window" over the shape of double escaping peak is tested.

Key words Pair spectrometer.

DEPTH PROFILING OF TRITIUM IN TITANIUM TRITIDE TARGETS

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7,
No 3, Aug 85 pp 279-283

[English abstract of article by Zhao Guoqing [6392 0948 1987], et al., of Fudan University, Shanghai]

[Text] Depth profiles of tritium in titanium tritide targets are determined by using Rutherford backscattering technique and Bragg's additivity rule of the stopping cross sections for T-Ti targets. For backscattering spectra of 2 MeV $^4\text{He}^+$ ions from two T-Ti targets, atom ratios of tritium to titanium at the surface of samples are calculated to be 1.50 ± 0.10 and 0.94 ± 0.08 respectively. Depth distributions of atom ratio of T/Ti in a region of $8000\text{\AA}$ under the surface of samples are nearly uniform with a discrepancy of ± 3 percent. The detection limit of T in the T-Ti targets is ~ 40 at percent. The depth resolution of this analytical method is about $300\text{\AA}$ at the surface region.

Key words Tritium depth profiling, ^4He , RBS, Proton Elastic scattering.

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CSO: 4009/95

ON THE THEORY OF A KIND OF PROBABILISTIC METRIC SPACES WITH APPLICATIONS

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese No 1, 1986 pp 1-6

[English abstract of article by Zhang Shisheng [1728 4258 3932]]

[Text] Our purpose is to introduce the concept of C-probabilistic metric spaces. By virtue of its some basic properties, we obtain some new fixed point theorems. (Paper received 25 Apr 84.)

REFERENCES

- [1] B.Schweizer, A.sklar, Probabilistic Metric Spaces, North-Holland, New york, Amsterdam, Oxford, 1982.
- [2] 张石生 中国科学, A辑, 1983,495—504.
- [3] V.M.Sehgal, A.T.Bharucha-Reid, Mathematical Systems Theory, 62(1972), 97—102..

COMPACTNESS IN FUZZY UNIT INTERVAL

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATIONAL SCIENCE EDITION)] in Chinese No 1, 1986 pp 40-44

[English abstract of article by Dian Jianwei [0368 1696 0251]]

[Text] Set L be a completely distributive lattice which has a smallest element 0 , a largest element $1(0 \neq 1)$ and a reverse order involution $\alpha \mapsto \alpha'$ ($\alpha \in L$).

Let $L^c = \{\alpha \in L : \alpha \text{ is comparable to each } \beta \in L\}$. Then, i) the fuzzy unit interval is α -compact, for all $\alpha \in L^c$; ii) $I(L)$ may be a non- α^* -compact space, if L be ortho-complementary and $0 < \alpha < 1$. (Paper received 21 Dec 83.)

REFERENCES

- [1] Hutton, B., J.Math.Anal.Appl., 50(1975), 74-79
- [2] Gantner, T.E., Steinlage, R.C. and Warren, R.H., J.Math.Anal.Appl., 62(1978) 547-562
- [3] 刘应明, 科学通报(数、理、化专辑), (1980), 33-35

THE ELECTRICAL RESISTANCE STUDY OF AMORPHOUS ALLOY $\text{Fe}_{80}\text{B}_{20}$ IN THE PROCESSES OF CRYSTALLIZATION AND STRUCTURAL RELAXATION

Guangzhou ZHONGSHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI] in Chinese No 2, May 86 pp 53-57

[English abstract of article by Wang Yunxin [3769 6663 2450], et al.]

[Text] The change of resistance in the process of ascending temperature for metallic glass $\text{Fe}_{80}\text{B}_{20}$ was measured as a function of temperature by four-terminal method. Both structure relaxation process (lower temperature region) and crystallization process (high temperature region) were observed. In the process of structure relaxation, $\Delta\rho/\rho$ varies with temperature as T^{-1} , but deviates linear in the temperature range of 450-550K and the maximum deviative of $\Delta\rho/\rho$ from T^{-1} is about 0.5% (R.T)

The amorphous/crystalline transformation takes place in two stages and in distinct regions of temperature. The isothermal crystallization kinetics was studied in these two distinct regions of temperature and the crystallization activation energy is 3.0eV and 1.0eV respectively. (Paper received Oct 85.)

REFERENCES

- (1) 林德明等, 贵金属, 2(1981), 4, 24.
- (2) F. J. Ohkawa, *J. Phys. SOC. Japan*, 44(1978), 1105.
- (3) D.A. Newetal, *J. Appl. Phys.*, 50(1979), 1854.
- (4) N. Banerjee et al., *Phys. Rev.*, 24(1981), 6801.
- (5) J. Orehotzky, *J. Appl. Phys.*, 50(1979), 7612.

STRENGTHENING AND TOUGHENING MECHANISMS OF MARAGING STAINLESS STEEL

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 2, Apr 86 pp 27-36

[English abstract of article by Cao Yang [2580 7122], et al., of Dept. of Materials Science and Engineering]

[Text] The strengthening and toughening mechanism of maraging stainless steel after thermo mechanical treatment (TMT) has been investigated with steel 00Cr12Ni9Cu2TiNbBeRE. According to experimental data and theoretical analysis, the quantitative relationships are obtained both between yield strength and parameters of TMT, and between yield strength and microstructural parameters. By means of energy-analysis, an expression of the impact toughness and microstructural parameters has been given. Hence the microstructural factors controlling strength and toughness are precipitate, martensitic microstructure and cellular substructure. A theoretical foundation has finally been obtained for the design of treatments' processing. (Paper received 1 Apr 85.)

REFERENCES

- [1] Anti-Corrosion, Methods and Marterials, Vol.1, №2, (1966), 7.
- [2] Crawford, W. M., Contractor, G. P., JISI, Vol.207, №12, (1969), 1642.
- [3] Caton, R. L., Cobalt, Vol.6, №55, (1972), 92.
- [4] Cadowaki, E. P., Met. Eng. Quart., Vol.2, №2, (1972), 47.
- [5] 许清池, 陈复民, 李国俊, 姚家鑫, 高后秀, 秦世麒, 仪表材料, Vol.15, №1, (1984), 14.
- [6] 曹 阳, 形变热处理对 00Cr12Ni9Cu2TiNbBeRE 马氏体时效不锈钢组织和性能影响的研究, 天津大学硕士论文, 1984.
- [7] McMahon, J., Thomas, G., Third Intern. Conf. on Strength of Metals and Alloys, 'Microstructure and Design of Alloys', Vol.1, 1973, P.180.
- [8] May, I. L., Schetky, L. M., Copper in Iron and Steel, JOHN WILEY & SONS, 1982, P.21.
- [9] Honeycombs, R. W., Pickering, F. B., Metall. Trans., Vol.3, №5, (1972), 1099.
- [10] 冈田康孝, 邦武立郎, 鉄と鋼, Vol. 67, №6, (1981), 791.
- [11] Norström, L. - Å., Scand. J. Metallurgy, Vol.5, №4, (1976), 159.
- [12] Bergström, Y., Josefsson, Å., Scand. J. Metallurgy, Vol.3, №4, (1974), 259.
- [13] Naylor, J. P., Metall. Trans., Vol. 10A, №7, (1979), 861.
- [14] Gleiter, H., Acta Metall., Vol.15, №8, (1967), 1223.
- [15] Gleiter, H., Hornbogen, E., Mater. Sci. Eng., Vol.2, №6, (1968), 285.

- [16] Kelly, A., Intern. Mater. Rev., Vol.18, №1, (1973), 31.
- [17] Kocks, U. F., Acta Metall., Vol.6, №1, (1958), 85.
- [18] 赵志业, 金属塑性变形与轧制理论, 冶金工业出版社, 1980, P.28.
- [19] 肖纪美, 金属的韧性与回火, 上海科学技术出版社, 1980, P.260.

RELATIONSHIP BETWEEN HEAVY METAL POLLUTION AND WATER PRODUCTIVITY IN XIAMEN ESTUARINE HARBOR

Beijing HAIYANG YU HUAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 17, No 3, May 86 pp 173-184

[English abstract of article by Wu Yudian [0702 3842 4551], et al., of Xiamen University]

[Text] Based upon the results of simulation experiments and annual observation on the effect of Cr, Cu, Hg, Zn, on diatom (*Chaetoceros* spp., *Skeletonema costatum*, and *Melosira sulcata*) growth, many physico-chemical parameters are found to play a considerable role in the toxicity and accumulation of metal in organisms especially in laboratory experiment. The Mesopic level in water environment is related to phytoplankton growth, whereas the higher nutrient level could have a negative impact on diatom production. Several metals mentioned above co-exist in the investigated region and exert an antagonistic effect.

We employed the mathematical statistics-orthogonal design in simulation experiments of 6 parameters (Cr, Cu, Hg, Zn, O.M., N/P) with three levels per parameter system for diatom culture. It showed that (1) the range of content of heavy metals is as follows: Cr 10-30, Cu 0.5-50, Hg 0.02-1.5, Zn 20-100 and (2) the optimal nutrient contents: N 100-250, P 25-40, O.M. 100,000 (all in ppb).

We observed these parameters, total phosphorus content, ratio of T-N/T-P (in atom) and Chlorophyll content in the investigated region for one year, and found that ranges of these data were 24-35ppb-P, 10-18T-N/T-P, and 10-20 mgm⁻³ Chlorophyll (cell numbers of phytoplankton are about 10⁶ cells/L) in all probability. (Paper received 8 Jul 84.)

REFERENCES

- [1] Betz, M., 1977. Investigations on the simultaneous uptake and release of mercury by *Dunaliella tertiolecta*. *Mar. Biol.* 41(1): 89-97.
- [2] Fisher, N. S. and J. G. Fabris, 1982. Complexation of Cu, Zn, and Cd by metabolites excreted from marine diatom. *Mar. Chem.* 11(3): 245-255.
- [3] Fisher, N. S., 1981. Heavy metals and marine phytoplankton correlation of toxicity and sulphhydryl binding. *J. Phycol.* 17(2): 108.
- [4] Fisher, N. S. and D. Frood, 1980. Heavy metals and marine diatoms: Influence of DOC on toxicity and selection for metal tolerance among four species. *Mar. Biol.* 99(2): 85-93.
- [5] Gaering, J. J., D. Boisseau and D. Mattor, 1977. Effects of Copper on silicic acid uptake by a marine phytoplankton population: CEPEX. *Bull. Mar. Sci.* 27(1): 58-63.
- [6] Hollibaugh, J. T., 1980. A comparison of the acute toxicities of ten heavy metals to phytoplankton for Saunich Inlet, B. C. *Canada, Estua. Coast. Mar. Sci.* 10(1): 93-103.
- [7] Kuiper, J., 1982. Ecotoxicological experiments with marine plankton communities in plastic bags. In: *Marine Mesocosms*. Grice, G. D. and M. R. Reeve ed. Chapter 13, Springer-Verlag N. Y. Inc. pp. 357-384.
- [8] Malone, T. C., 1982. Factors influencing the fate of sewage-derived nutrients in the lower Hudson estuary and N. Y. Bight. In: *Ecological Stress and the N. Y. Bight: Science and Management*. Mayer, G. F. ed. Estuarine Research Federation Columbia, S. Carolina. pp. 389-412.
- [9] Patin, S. A., 1982. Effect of pollutants on cultured unicellular marine algae. In: *Pollution and the Biological Resources of the Oceans*. Chapter 6, Butterworth Scientific. pp. 80-109.
- [10] Rueter, Jr. J. G. and F. M. M. Morel, 1981. The interaction between Zinc deficiency and copper toxicity as it affects the silicic acid uptake mechanisms in *Thalassiosira pseudonana*. *Lim. Ocean.* 26(1): 67-73.

- [11] Rueter, Jr. J. G., S. W. Chisholm and F. M. M. Morel, 1981. Effects of copper toxicity on silicic acid uptake and growth in *Thalassiosira pseudonana*. *J. Phycol.* 17(3): 270—278.
- [12] Sunda, W. G. and R. R. L. Guillard, 1976. The relationship between cupric ion activity and the toxicity of copper to phytoplankton. *J. Mar. Res.* 34(1): 34—40.
- [13] Thoms, W. H., J. T. Hollibaugh, D. L. R. Seibert et al, 1980. Toxicity of a mixture of ten metals to phytoplankton. *Mar. Ecol. Prog. Ser.* 11(3): 213—220.
- [14] Yamada, M. 1982. Effects of industrial effluents containing organic material such as dyestuff on the growth of several species of marine phytoplankton. *Bull. Jap. Soc. Sci. Fish.* 48(10): 1453—1456.

CHARACTERISTICS OF TIDAL CURRENT AND SEDIMENTATION OF SUSPENDED LOAD ON TIDAL MUD FLAT IN JIANGSU PROVINCE

Beijing HAIYANG YU HUZAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 17, No 3, May 86 pp 235-245

[English abstract of article by Shang Renshun [1728 1804 7311] of Nanjing University]

[Text] The prograding tidal mud flat in Jiangsu Province is perhaps the widest and longest in China. It belongs to the open (north part) or semi-open (south part) tidal flat and is of moderate-high tidal range.

Four profiles of tidal mud flat in Jiangsu Province were dealt with. A 25-hours survey of the whole tide hydrography was carried out for each profile. Based on those investigations, the characteristics of tidal current and concentration of suspended sediment on tidal mud flat were analyzed. The distribution of concentration of suspended sediment was different from that of current velocity along the profiles, the concentration of suspended sediment was highest near low water line but decreased toward the sea and the high water line, however the velocity decreased from offshore to high water line. The tidal current was rectilinear in offshore tidal channel, but rotary on tidal mud flat; and the direction of residual transport of water and sediment on upper intertidal zone contrasted strikingly with that on lower intertidal and subtidal zone.

The lag mechanism could explain some features, but not all the main phenomena of sedimentary processes taking place on tidal flat in Jiangsu Province unless introducing wave and storm surge effect. It is notable that the horizontal residual circulation of water and suspended load is present on tidal flat. As a result, the wide tidal mud flat is divided into a series of longshore cells which form individual dynamic units. (Paper received 9 Oct 84.)

REFERENCES

- [1] 任美铎、张忍顺、杨巨海, 1984. 江苏王港地区淤泥质潮滩的沉积作用. 海洋通报 3(1): 40-54.
- [2] 任美铎、张忍顺、杨巨海等, 1983. 风暴潮对淤泥质海岸的影响. 海洋地质与第四纪地质 3(4): 1-24.
- [3] 张忍顺, 1984. 苏北黄河三角洲及滨海平原的成陆过程. 地理学报 39(2): 173-184.
- [4] Bayliss-Smith, T. P., R. Healey, R. Lailey et al., 1979. Tidal flows in salt marsh creek, *Estuar. Coast. Sci.* 9: 235-255.
- [5] Carling, P. A., 1982. Temporal and spatial variation in intertidal sedimentation rates. *Sedimentology* 29(1): 17-23.
- [6] Collins, M. B., C. L. Amos and G. Evans, 1981. Observation of some sediment-transport processes over intertidal flat. *Sediment* 3: 81-98.
- [7] Göhren, H., 1976. Currents in tidal flats during storm surges. Proc. of the 15th Coastal Engineering Conf. New York, American Society of Civil Engineers. vol. 2, pp. 959-970.
- [8] Häntschel, W., 1939. Tidal flat deposits, Holocene Tidal Sedimentation (Ed. Klein, G. dev.), DH and R. pp. 14-24.
- [9] Inman, D. L. and B. M. Brush, 1973. The coastal challenge. *Science* 181: 20-32.
- [10] Kestner, F. J. T., 1975. The Loose-boundary regime of the Wash. *The Geograph. J.* 141(3): 388-414.
- [11] Pethick, J. S., 1980. Velocity surges and asymmetry in tidal channel. *Estuar. Coast. Mar. Sci.* 11(3): 331-345.
- [12] Postma, H., 1954. Hydrography of the Dutch Wadden Sea. *Arch. Néerl. Zool.* 10: 405-511.

- [13] Postma, H. 1961. Transport and accumulation of suspended matter in the Dutch Wadden Sea. *Netherlands J. Sea Res.* 1(1/2): 148—190.
- [14] Postma, H. 1967. Sediment transport and sedimentation in the Estuarine Environment. Estuarine (Ed. by H. Lauff). AAS. pp. 158—179.
- [15] Postma, H. 1962. Hydrography of the Wadden Sea: Movements and Properties of Water and Particulate Matter. Printed in the Netherlands. Chapt. 2, pp. 18—19; 34—47.
- [16] Ren Mele, Zhang Renxun and Yang Juhai, 1983. Sedimentation on tidal mud flat of Wanggang Area, Jiangsu Province, China. *Collected Oceanic Works* 6(2): 84—108.
- [17] Streaten, K. N. J. U. Van and Ph. H. Kuenen, 1958. Tidal action as a cause for clay accumulation. *J. Sed. Petrol.* 28: 406—413.
- [18] Wells, J. T. 1978. Suspension and transportation of fluid mud by Solitary-Like waves. Proc. of 16th Coastal Engineering Conf. New York, American Society of Civil Engineers. vol. 2, pp. 1932—1972.
- [19] Wells, J. T. 1983. Dynamics of coastal fluid muds in low-, Moderate-, and high-tidal range environment. *Can. J. Fish. Aquat. Sci.* 40(Suppl. 1): 130—142.

A PRELIMINARY STUDY ABOUT SEPARATION AND FORECAST OF THE CURRENT MASS TRANSPORT

Beijing HAIYANG YU HUZAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 17, No 3, May 86 pp 246-259

[English abstract of article by Shen Lingyun [3088 0407 0061] of Nanjing Chemical Technological School, and Zhao Baoren [6392 0202 0088] of Institute of Oceanology, Academia Sinica, Qingdao]

[Text] It is presumed that the mass transport of current is composed of constant current and wind drift current, of which the mass transport of the constant current is invariable in a short period, and that the wind factor and current deviation angle of the wind drift mass transport vary with wind direction. The wind factor with current deviation angle of mass transportation can therefore be decomposed into north wind factor with current deviation angle and east wind factor with current deviation angle. In general the above four elements of the wind drift mass transport as well as two constant current elements are called the six elements of current mass transport.

With three sets of observations of wind and current vectors and depth and density made at different times and by solving six linear algebraic equations, the six elements of mass transport can be obtained. From the obtained formula for the wind factors and current deviation angles of the mass transport it is shown that the orbit of the current vectors is an ellipse when the wind direction varies.

All the previous methods for the separation of the wind drift current are confined to current vectors. We introduce the concept of current mass transport for the separation of the drift current. The previous methods for separations of the wind drift current are special cases of the present method. Without the influence of density, it turns to volume separation method, yet with the volume transport of the unit thickness only, it turns to the method of the separation of wind drift current ellipse. In the deep sea area far from coast, when the wind factor and current deviation angles are independent of wind direction a cycle will be found. So the present method can be regarded as a generalization of all previous methods of residual current separation.

As an example, the wind factors and the current deviation angles are calculated and tabled for every layer and for all the 16 azimuths of the station A near the coast in the northern East China Sea. According to the wind forecast, the wind drift current can be predicted by the tables and simple calculation. This method is useful for predicting the current in the lake also.

Comparing the predicted residual current with measured one, they are in good agreement. The errors are 22 percent for the magnitudes and 31° for directions of the residual current in average, respectively. (Paper received 21 Nov 84.)

REFERENCES

- [1] 赵保仁, 1982. 确定近岸风海流椭圆的一个简单方法. 海洋科学 1982(2) 41-43.
- [2] 赵保仁, 1982. 局地风对黄海和东海近岸浅海海流影响的研究. 海洋与湖泊 13(6): 479-490.
- [3] Nansen, F., 1902. The Norwegian North Polar Expedition 1893-1896. Vol. III, pp. 358-359.
- [4] Sverdrup, H. U., 1936. The Wind-Drift of the Norwegian North Polar Expedition with the "Mond" 1918-1925. pp. 18-19.

AN EMPIRICAL FORMULA FOR SCATTERING PROPERTY OF FILM FOR PSEUDOCOLOR ENCODING OF IMAGE

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATIONAL SCIENCE EDITION)] in Chinese No 1, 1986 pp 45-50

[English abstract of article by Chen Zexian [7115 3419 0341] and Su Xianyu [5685 7359 3254]]

[Text] Real-time pseudocolor effect resulted from scattering of film emulsion is described. The scattering properties of Chinese-made medical X-ray film is studied, and an empirical formula for describing the properties is given. The experimental result is in a good coincidence with theoretical analysis. The real-time pseudocolor enhancement technique is used for processing of medical X-ray photograph, the resulting output hue curve and some other results are given. (Paper received 27 Sep 84.)

REFERENCES

- [1] H.K.Liu, J.W.Goodman, S.P.I.E., 83(1976), 125.
- [2] F.T.S.Yu, A.Tai and H.Chen, J.Opt., 9(1978), 269.
- [3] T.H.Chao, S.L.Zhuang, F.T.S.Yu, Opt.Lett., 5(1980), 230.
- [4] 郭履容等, 光学学报, 4(1984), 145.
- [5] R. Arizaga, N. Bolognini, H. J. Babal, E. E. Siere and M. Garavaglia, Opt.Comm., 43(1982), 12.
- [6] J.A.Mendez and M.Nieto-vesperinas, Appl.Opt., 22(1983), 2068.
- [7] P.Beckmann and A.Spizzichino, The Scattering of Electromagnetic Waves from Rough Surfaces, Pergamon, New York, 1963.
- [8] H.M.Smith, Appl. Opt., 11(1972), 26.

A DOUBLE CORRELATION TECHNIQUE FOR COUNTING RED BLOOD CELLS

Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATIONAL SCIENCE EDITION)] in Chinese No 1, 1986 pp 51-55

[English abstract of article by Zhong Yongbi [6988 3057 4310], et al.]

[Text] The optical double correlation is a new technique not using a holographic matched filter. The principle applied to erythrocyte counting and the experimental system are described. The experimental results are given. The experimental results are in agreement with the theoretical analysis. (Paper received 2 Nov 84.)

REFERENCES

- [1] J.E.Ward, F.P.Carison and J.D.Heywood, IEEE Trans.Biom.Eng.BME-21(1974), 12.
- [2] S.Jutamulla, H.Fujii and T.Asakura, Opt Commun., 43(1982), 7.
- [3] 赵霖, 张洪钧, 物理学报, 31(1981), 143.

THEORETICAL STUDY ON STABILIZATION OF F_2^+ CENTERS BY O^{--} IN LiF CRYSTALS

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 2,
Apr 86 pp 17-26

[English abstract of article by Ruan Yongfeng [7086 3057 0023] and Wan Liangfeng
[8001 5328 7364] of Department of Physics]

[Text] This paper studies the stabilization of F_2^+ centers by O^{--} in LiF crystals. According to the pattern of energy cycle suggested in this paper the stable energy is calculated by means of HWW model, point charge model and quantum-mechanics perturbation method. The results show that O^{--} reduces the electron affinity energy of F_2^+ centers on the one hand and increases their binding energy on the other hand. It is because of this dual nature that the stability of F_2^+ centers rises in LiF crystals doped with oxygen. The theoretical value of the stable energy given is in good agreement with the experimental one in the condition of chosen parameter. So far no similar work has been reported. (Paper received 12 Mar 86.)

REFERENCES

- [1] В.Д.Лобонов и др., Изв. ВУЗ, физика, 4, 81, (1978)
- [2] 阮永丰 万良风 郭绍章, «掺氧LiF晶体中 F_2^+ 心稳定性的实验研究», 发表于《中国激光》第10卷第5期第269页(1983年)及《Chinese physics》(edited by American Institute of Physics) Vol.3, №4, P.1014
- [3] В.А.Архангельская и др., Квантовая Электроника, 7, 1141, (1980)
- [4] 郑立行等, «LiF晶体中 F_2^+ 心的形成», 全国第七届晶体生长与材料会议论文, 1985年10月, 烟台
- [5] R. C. Herman, M. C. Wallis, R. F. Wallis, Phys. Rev., 103, 87, (1956)
- [6] M. A. Aegerter & F. Lüty, Phys. Stat. Sol. (b), 43, 227, (1971)
- [7] 何健, « F_2^+ 心电子的能态», 上海市物理学会1983年物理学应用研究成果交流报告会论文, 1983年7月
- [8] J. H. Crawford, J. Phys. Chem. Sol., 31, 399, (1969)
- [9] 唐放庆等, «量子化学», 科学出版社出版, (1982年)
- [10] J.C. Slater, «Quantum Theory of Molecules and Solids» Vol.1, App.6
- [11] W. Kolos, L. Wolniewicz, J. Chem. Phys., 43, 2429; (1965) and 45, 509 (1966)
- [12] D.R. Bates, Ledsham and Stewart, Phil. Trans. Roy. Soc. (London), A246, 215, (1954)
- [13] И. А. Парфянович и др., Изв. Академии наук СССР, Сер. Физ. 43, 1125, (1979)
- [14] Axel Meyer, R. F. Wood, Phys. Rev., 133, A1436, (1964)
- [15] L. F. Mollenauer, "Color Center Lasers", in «Methods of Experimental Physics» Vol.15, Part B, edited by Tang. C. L., New York, (1979)

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